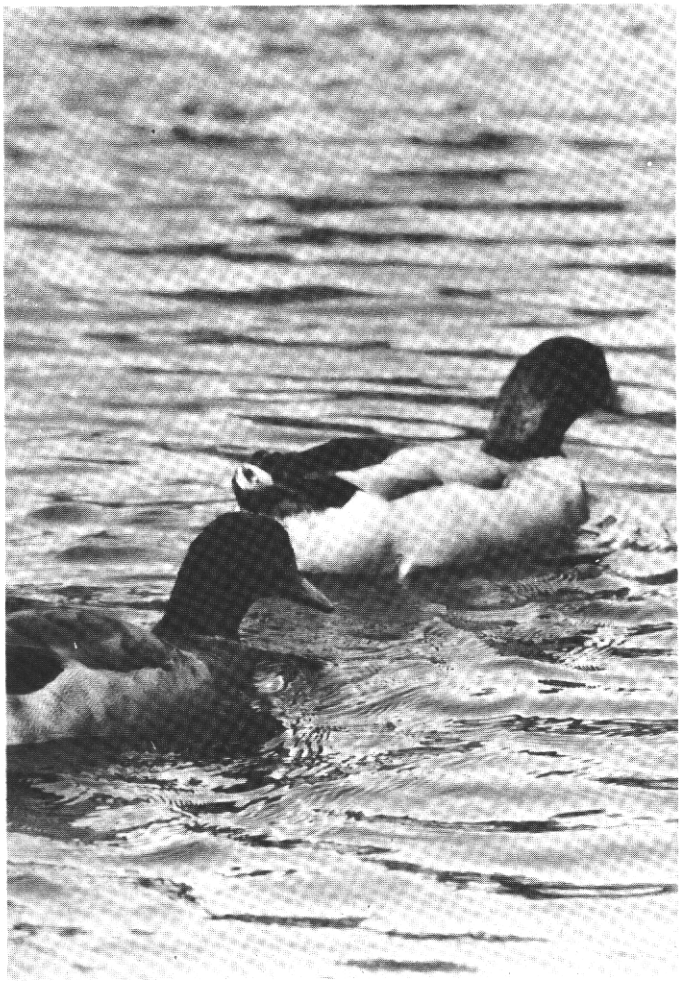
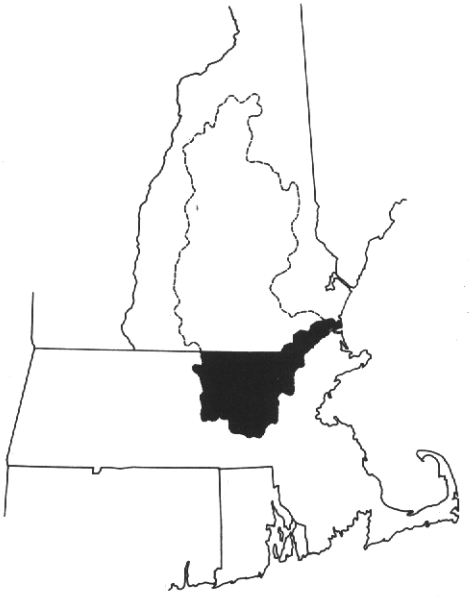
MERRIMACK WASTEWATER MANAGEMENT

key to a clean river



APPENDIX IV-B

BIOLOGICAL IMPACTS
Volume 2



NORTHEASTERN UNITED STATES WATER SUPPLY STUDY

NOVEMBER 1974

MERRIMACK WASTEWATER MANAGEMENT
INDEX TO REPORT VOLUMES

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MERRIMACK WASTEWATER MANAGEMENT

(KEY TO A CLEAN RIVER)

APPENDIX IV-B

ENVIRONMENTAL CONDITIONS IN THE MERRIMACK RIVER WATERSHED, MASSACHUSETTS,

and Probable Impacts of Wastewater Management Alternatives

(Volume 2)

November 1974

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APPENDIX A
Aquatic Field Notes, Fall, 1973

Site 1 MERRIMACK B-8273

NEWBURYPORT, ESTUARY

QUADRANGLE: Newburyport, East

DATE: 8 October 1973

TIME: 1430

WEATHER: Bright and Sunny

DEPTH, MID-CHANNEL: 13 feet

TEMPERATURE PROFILE, MID-CHANNEL:

Surface:	57.5°F
Mid-Water:	57.5°F
Bottom:	57.0°F

D.O.: Surface: 7.0 mg/l Bottom: 6.8 mg/l

FLOW RATE: Tidal-not measured

TURBIDITY: 1.6 J.T.U.

TRANSPARENCY: 8 feet

CONDUCTIVITY:

Surface:	18.7 millimohs/cm^2
Mid-water:	20.51 millimohs/cm^2
Bottom:	21.88 millimohs/cm^2

SALINITY:

Surface:	14.2 $^{0}/_{oo}$
Mid-water:	15.7 $^{o}/_{oo}$
Bottom:	17.0 $^{o}/_{oo}$

SITE 1 Continued

SUBSTRATE TYPES:

Three distinct substrate types were sampled. Sandy mud, very high in clay size particles, occurred at the northern tidal flat station.

A mid-channel deposit of highly organic, black, fine grain material associated with wood (natural) fragments. Obviously of terrestrial/fresh water origin.

Zostera stands were observed to be abundant on the Joppa Flats. Also observed were burrows of infaunal organisms. The dominant organisms were Polychaete Annelids.

OVERHANGING VEGETATION: None

LITTORAL AREA:

The tidal flat areas are very extensive throughout the estuary.

FISH HABITAT:

From available data we know that the Merrimack estuary supports a diverse and abundant fish community.

OUTFALLS: None noted

GENERAL AESTHETICS:

Very good. The expanse of salt marsh adds much beauty.

POSSIBLE VALUE AS "SLUDGE" SITE:

Evidence from initial sampling indicates possible mid-channel deposit. A. D. Hartwell also found this type of deposit and attributes it to storms. This seems reasonable. It also seems reasonable to suspect this deposit to contain pollutants.

SITE 2 POWWOW RIVER B-8264

Amesbury, Massachusetts Main Street Bridge

QUADRANGLE: Newburyport, W.

DATE: 27 September 1973

TIME: 1140

WEATHER: Bright and sunny

DEPTH, MID-CHANNEL: 6 feet

TEMPERATURE PROFILE, MID-CHANNEL: 62.1 isothermal

D.O.:

Surface: 7.3 mg/l
Bottom: 7.5 mg/l

FLOW RATE: 0.5 f.p.s. (tidal) (incoming tide)

TURBIDITY: 2.0 J.T.U.

TRANSPARENCY: 3 feet

CONDUCTIVITY:

Surface: 0.21 millimohs/cm^2
Bottom: 0.22 millimohs/cm^2

SALINITY: 0.3 $^{o}/oo$

SUBSTRATE TYPE:

The substratum at this site is similar to site 9. Deposit generally fine grain with large amount of plant debris. The plant material is not well degraded.

LITTORAL AREA: Varies greatly depending on state of tide.

OVERHANGING VEGETATION: Not extremely abundant.

FISH HABITAT:

The presence of dense aquatic vegetation provides good fish cover. Sparse windfalls.

SITE 2 continued

OUTFALLS: None noted

GENERAL AESTHETICS:

Extensive channelization and modification to suit the demands of interstate highway 495 degrades the appearance of this river greatly. It is classified as fair to poor.

POSSIBLE VALUE AS "SLUDGE" SITE:

Value minimal since it is a very minor tributary to the Merrimack. It is however a sediment entrapping area as is its short easterly branch.

REMARKS:

Sandpipers very probably are important predators on infaunal benthos in littoral zone.

SITE 3 MERRIMACK B-8272

Haverhill, Groveland Street Bridge

QUADRANGLE: Haverhill

DATE: 8 October 1973

TIME: 0900

WEATHER: Bright and sunny

DEPTH, MID-CHANNEL: 13 feet

TEMPERATURE PROFILE, MID-CHANNEL: 61°F isothermal

D.O.:

Surface: 5.1 mg/l
Bottom: 5.0 mg/l

FLOW RATE: Below resolution

TURBIDITY: 4.8 J.T.U.

TRANSPARENCY: 3.5 feet

CONDUCTIVITY:

Surface: 0.46 millimohs/cm^2
Mid-water: 0.48 millimohs/cm^2
Bottom: 0.47 millimohs/cm^2

SALINITY:

Surface: 0.00 $^{o}/oo$
Mid-water: 0.22 $^{o}/oo$
Bottom: 0.22 $^{o}/oo$

SUBSTRATE TYPES:

Two distinct substrate types were sampled. Fine to medium sand, densely packed, associated with some organic material and silt is the dominant littoral substrate. The mid-channel deposit is very coarse and coarse sand with some fine gravel and small boulders.

LITTORAL AREA: Approximately 4-5 feet in width

SITE 3 Continued

OVERHANGING VEGETATION:

Abundant upstream of Groveland Street Bridge. Mainly overhanging branches of larger trees.

FISH HABITAT:

Generally fair to moderate as littoral zone is not extensive, however some areas could be considered good.

OUTFALLS NOTED:

One outfall was noted downstream from the sampling site. The observed outfall is from a waste paper processing plant of the Continental Can Company. Waste material from the plant is discharged as macro-fragments and colloidal particles. This outfall has formed a relatively extensive deposit of paper reprocessing wastes. The discharge is also, in part, transported downstream by way of a narrow channel south of Porter Island and then discharged into the main channel at the western end of this back channel. A distinct milky, brownish-white coloration was observed in the immediate vicinity of the outfall. This discharge also discolors the river upstream, giving it a milky cast. Larger fragments of paper waste are also transported away from the outfall.

In addition to this outfall several others were identified by Mr. W. J. Slavit, Riverside Airport, Haverhill, Massachusetts. These sources are listed below.

SOURCE	TYPE OF WASTE DISCHARGED
Merrimack Paving	Particulate Matter
Dump	Run-off Water
Hoyt & Worthen Tannery	Animal Fat and Hair
Continental Can Co.	Acid and Paper Waste
General Split Co.	Animal Fat and Hair
Jameson Chemical Co.	General Chemical Waste
Bixby Co.	Animal Fat and Hair
L. H. Hammel Tannery (Little River)	Animal Fat and Hair

In addition to these industrial outfalls several sewage outfalls were also identified.

SITE 3 (continued)

GENERAL AESTHETICS:

The appearance of the river is quite poor in the immediate vicinity of Haverhill. Upstream, however, less pollution is evident and the general setting is much more pleasant. The overall rating is fair to poor.

POSSIBLE VALUE AS "SLUDGE" SITE:

The abundance of outfalls indicates that "sludge" deposits should be common at this site.

SITE 4 MERRIMACK RIVER B-8292

Lawrence, Massachusetts Essex Dam

QUADRANGLE: Lawrence

DATE: 24 September 1973

TIME: 0900

WEATHER: Cloudy, overcast, rain

DEPTH, MID-CHANNEL: 21 feet

TEMPERATURE PROFILE MID-CHANNEL: 62° isothermal

D.O.:

Surface: 6.4 mg/l
Bottom: 6.0 mg/l

FLOW RATE: 0.4 f.p.s.

TURBIDITY: 2.4 J.T.U.

TRANSPARENCY: 4 feet

SUBSTRATE TYPES:

CHANNEL NEAR DAM: Predominately fine and medium sand with some organic debris, predominantly plant fragments. Rock and cobble has been placed along river banks for erosion control. Upstream of the dam two distinct substrates occur. On the north bank a high organic fine grain deposit is present. It seems likely that the predominant source of organic material is natural plant debris. The substrate of the south bank is mainly low organic, highly compacted clay and sand. These observations make sense within the context of inside bend (depositional); outside bend (erosional) environments. The back water areas have a characteristic high organic fine grain substrate. The plant fragments in this deposit exhibit a less decayed state relative to the high organic deposits of the north bank. This is in all likelihood due to the probably higher rate of deposition in the back water areas.

OVERHANGING VEGETATION:

Abundant overhanging vegetation, provided mainly by various trees and shrubs, is present along the river banks. The backwater areas do not have substantial overhanging vegetation.

SITE 4 Continued

FISH HABITAT:

Windfalls along the river banks provide good cover for fish, while the abundant overhanging vegetation provides needed shade. The backwater areas are also a good fish habitat due to the abundance of aquatic vegetation in this environment, especially Nymphae. Fish were observed jumping in the backwater areas during the survey.

OUTFALLS:

One outfall was noted on the south bank approximately 1/3 of the distance from the dam to the powerline upstream. Some scum was observed on the water surface adjacent to the outfall.

LITTORAL AREA: Minimal, very little shallow water.

GENERAL AESTHETICS:

The general aesthetic value of the site is classified as fair. Looking upstream from the dam the appearance of the site is generally pleasing. However, the downstream view is spoiled by urban/industrial influences. The presence of junk, especially discarded shopping carts, and various trash and garbage also greatly lessens aesthetic appeal.

VALUE AS "SLUDGE" SITE:

It would seem reasonable to assume the "sludge" being transported by the Merrimack River should in part be deposited behind the Essex Dam. Substrate exploration so far has failed to yield any easily identifiable "sludge" deposits. The only likely deposits identified by this preliminary survey are those identified under "substrate types" as having a high organic content--North bank, upstream and backwater areas.

SITE 5 MERRIMACK B-8271

LOWELL, PAWTUCKET DAM

QUADRANGLE: Lowell

DATE: 5 October 1973

TIME: 1100

WEATHER: Overcast with light rain

DEPTH, MID=CHANNEL: 15 feet

TEMPERATURE PROFILE, MID-CHANNEL: 63.1° isothermal

D.O.:

Surface: 6.6 mg/l
Bottom: 6.6 mg/l

FLOW RATE: Apparent but below resolution

TURBIDITY: 1.8 J.T.U.

TRANSPARENCY: 5 feet

SUBSTRATE TYPES:

Two distinct substrate types were found. At the north and mid-channel stations a well sorted deposit of very fine sand associated with very little organic debris but with some clay balls was located.

At the south station a very coarse sand and gravel deposit was located with associated large wood fragments.

LITTORAL AREA:

Approximately 8 feet to 10 feet in width-well packed fine sand substrate.

OVERHANGING VEGETATION: None

FISH HABITAT: Probably poor due to sparseness of aquatic vegetation.

OUTFALLS NOTED: None noted

GENERAL AESTHETICS: Very poor-great deal of floating debris with urban sprawl.

SITE 5 Continued

POSSIBLE VALUE AS "SLUDGE" SITE:

Probably none. Only evidence of deposition of fine grain material is from north station. At this site a dark coloration of a 2-3 cm surface layer of the deposit indicated recent fine deposition. Probably related to decreased discharge.

SITE 6 SQUANNACOOK B-8268

Townsend, Massachusetts Brookline Road

QUADRANGLE: Townsend

DATE: 2 October 1973

TIME: 1330

WEATHER: Slightly overcast

DEPTH, MID-CHANNEL: 5.5 feet

TEMPERATURE PROFILE, MID-CHANNEL:

Surface: 53.1°F
Mid-Water: 53.1°F
Bottom: 53.0°F

D.O.:

Surface: 8.9 mg/l
Bottom: 8.8 mg/l

FLOW RATE: Preceptable but ≈ 0.1 f.p.s.

TURBIDITY: 0.8 J.T.U.

TRANSPARENCY: 5.5 feet (to bottom)

SUBSTRATE TYPES:

Typical of this site is a poorly sorted sand (fine-coarse) and gravel bottom. The deposit fines south to north (outside to inside bend). The deposit is very low in contained organics. Due to the abundance of overhanging vegetation much branch and other woody material lies on the surface of the river bed.

LITTORAL AREA:

Approximately 2-3 feet wide with sharp slopes. Substrate is sand with wood fragment litter on surface.

OVERHANGING VEGETATION:

Very abundant, especially horizontal branches of larger trees.

SITE 6 Continued

FISH HABITAT:

Abundant windfalls, and aquatic vegetation make this river an excellent fish habitat.

OUTFALLS NOTED: None noted

GENERAL AESTHETICS:

The pristine nature and woodland setting of this river give it an excellent rating.

POSSIBLE VALUE AS "SLUDGE" SITE: None

REMARKS: Trout stocked

SITE 6A SQUANNACOOK B-8267

Townsend, Massachusetts Brookline Road (North)

QUADRANGLE: Townsend

DATE: 2 October 1973

TIME: 0900

WEATHER: Clear and sunny

DEPTH, MID-CHANNEL: 3 feet

TEMPERATURE PROFILE, MID-CHANNEL:

D.O.: 9.5 mg/l

FLOW RATE: Preceptable but < 0.1 f.p.s.

TURBIDITY: 1.0 J.T.U.

TRANSPARENCY: 3 feet (to bottom)

SUBSTRATE TYPE:

Slow water - sandy, fine material along banks very coarse in mid-channel. Low organics. Benthic sampling area cobble armored. Cobbles vegetation encrusted.

LITTORAL AREA: 8-10 feet wide; generally extensive with some deep pools.

OVERHANGING VEGETATION: None

FISH HABITAT:

Presence of riffle areas and associated downstream deep pools make this area an acceptable trout habitat. Aquatic vegetation sparse.

OUTFALLS: None

GENERAL AESTHETICS: Excellent; very pristine, fast, cold water.

POSSIBLE VALUE AS "SLUDGE" SITE: None

REMARKS: Alternative rocky small tributary control

SITE 7 SHAWSHEEN B-8265

Andover, Reservation Road Bridge

QUADRANGLE: Lawrence

DATE: 1 October 1973

TIME: 0830

WEATHER: Sunny and clear

DEPTH, MID-CHANNEL: Highly variable measurements at 3 feet

TEMPERATURE: 55.5° isothermal

D.O.: 5.7 mg/l

FLOW RATE: 1.4 f.p.s.

TURBIDITY: 0.9 J.T.U.

TRANSPARENCY: Clear to bottom (3 feet)

SUBSTRATE TYPES:

Shallow, rapid current areas characteristically have a cobble armored bottom of coarse and very coarse sand. Very little organic debris was observed. Deeper areas exhibited a sandy substrate type with very coarse material mid-channel fineing shoreward. Thin layers of fine grain high-organic deposits occurred in association with aquatic plants.

OVERHANGING VEGETATION: None

FISH HABITAT:

The abundance of non-emergent vegetation, especially *Potomogeton* sp. produces a good fish habitat.

OUTFALLS:

None noted, however, remarks of local inhabitants indicate a source of nutrients (possibly sewage) to be present.

SITE 7 Continued

LITTORAL AREA: Approximately 2 feet to 3 feet in width. sandy substrate.

GENERAL AESTHETICS:

This clear, fast-water stream has a great deal of aesthetic appeal and has been rated as very good.

VALUE AS "SLUDGE" SITE: None

REMARKS:

This river is probably not a good "control" stream. Reports from local inhabitants indicate a source of pollution. Personnel from Shawsheen Rubber Company stated that they had observed a brown foam scum behind their dam in late summer. They associated this with fish kills. Our own observations of dense filamentous algal coats on rocks also indicates a nutrient and/or pollution sources upstream of the site.

SITE 8 CONCORD RIVER B-8259

North Billerica, Massachusetts Pollard Street

QUADRANGLE: Billerica

DATE: 25 September 1973

TIME: 0900

WEATHER: Sunny and clear

DEPTH, MID-CHANNEL: 3 feet

TEMPERATURE PROFILE, MID-CHANNEL:

Surface: 59°F
Midwater: 58.9°F
Bottom: 58.9°F

D.O.: Midwater: 9.5 mg/l

FLOW RATE: 1.1 f.p.s.

TURBIDITY: 3.2 J.T.U.

TRANSPARENCY: 3 feet (clear to bottom)

SUBSTRATE TYPES:

Three distinct substrate types were sampled in the river channel. The east bank was comprised of organic debris and sand (predominantly coarse and very coarse) with some cobble. The mid-channel deposit was characteristically cobble and coarse sand. A well developed cobble armor was also found. Along the west bank marshy conditions prevail and their effect is mirrored by the peat-like deposit of poorly degraded plant fragments and debris.

The mill pond downstream exhibited a fourth substrate type. This deposit was well sorted material consisting of silt clay size particles and finely divided, highly degraded plant debris.

OVERHANGING VEGETATION:

Overhanging vegetation at the site was abundant, and was comprised predominantly of the branches of large trees. Although not classified as overhanging vegetation, the marsh vegetation present along stretches of the western bank provides a similar shading effect and was also abundant.

SITE 8 Continued

OVERHANGING VEGETATION (CONTINUED):

The downstream millpond, in contrast, had a paucity of overhanging vegetation.

FISH HABITAT:

Windfalls occurred in abundance along the banks of the river providing excellent cover. The *Potomogeton* beds adjacent to the Pollard Street Bridge also provide excellent fish habitat.

In the mill pond downstream the dense aquatic vegetation affords good fish cover.

Also excellent for turtles.

OUTFALL: No outfalls were noted at this site.

LITTORAL AREA:

The littoral zone along the river banks is approximately four feet wide in most areas. Marsh areas have no apparent littoral zone.

A similar littoral zone was also observed in the downstream mill pond.

GENERAL AESTHETICS:

The site has a generally pleasant appearance. Some trash is present but is not highly deleterious to the aesthetic value of the site.

VALUE AS "SLUDGE" SITE:

The downstream millpond is obviously acting as a fine-grain sediment entrapment basin. This would indicate a good probability of "sludge" entrapment.

SITE 9 CONCORD RIVER B-8260

Carlisle, Massachusetts Route 225 (Carlisle Road)

QUADRANGLE: Billerica

DATE: 25 September 1973

TIME: 1400

WEATHER: Sunny and clear

DEPTH, MID-CHANNEL: 8 feet

TEMPERATURE PROFILE, MID-CHANNEL:

Surface: 62.0°F
Mid-Water: 61.0°F
Bottom: 59.9°F

D.O.:

Surface: 8.9 mg/l
Bottom: 8.6 mg/l

FLOW RATE: Below Resolution < 0.1 f.p.s.

TURBIDITY: 2.8

TRANSPARENCY: 3.5 feet

SUBSTRATE TYPES:

A single substrate type was located at this site. Since the area is marshy the channel deposit consisted of fine grain material with a large amount of poorly degraded plant debris. The substrate was similar to that found on the west bank at site 8. The surface of this substrate is possibly partially stabilized by a filamentous algal mat. The bottom material is easily made thixotropic and has a high erosion potential.

OVERHANGING VEGETATION:

Being a marshy environment no overhanging vegetation was present. The vegetation comprising the marsh assemblage is similar to that at site 8.

FISH HABITAT:

The presence of marsh vegetation in the form of low lying shrubs with extensive underwater root systems provides a very good fish habitat.

SITE 9 Continued

OUTFALLS: None noted at this site

LITTORAL AREA: The littoral zone is approximately 10 feet in width

GENERAL AESTHETICS:

The appearance of the site is rather pristine. No trash was observed, and the site is rated as excellent.

VALUE AS "SLUDGE" SITE:

The slow moving nature of the river at this site combined with the marsh environment makes this site a natural basin of deposition. None of the bottom material recovered could be labeled as "sludge", however this site would entrap "sludge" if it were being transported by the Concord from an upstream source.

SITE 10 SUDBURY RIVER B-8262

Rt. 117 Bridge

QUADRANGLE: Concord

DATE: 26 September 1973

TIME: 1300

DEPTH, MID-CHANNEL: 6 feet

TEMPERATURE PROFILE, MID-CHANNEL:

Surface: 62.0°F
Mid-water: 61.1°F
Bottom: 60.0°F

D.O.:

Surface: 6.6 mg/l
Bottom: 6.3 mg/l

FLOW RATE: Less than resolution < 0.1 f.p.s.

TURBIDITY: 6.4

TRANSPARENCY: 2 feet

SUBSTRATE TYPES:

The predominant substrate type present at the site is finely divided, well degraded plant debris with silt-clay size particles. In general substrate is similar to site 9.

OVERHANGING VEGETATION: None noted

FISH HABITAT:

The abundance of aquatic vegetation and marsh vegetation (shrubs-similar to site 9) provides an excellent fish habitat.

OUTFALLS: None noted

LITTORAL AREA: Probably broad, but marsh vegetation precludes observation.

GENERAL AESTHETICS:

This site is in a National Wildlife Preserve and is very pristine in appearance. It is classified as excellent.

SITE 10 Continued

VALUE AS "SLUDGE" SITE:

Being a marsh area this site is a natural sediment trap. The sediment recovered from this site is high in organic content, but no evidence of "sludge" was apparent.

Fairhaven Bay, downstream from the site, is also a natural sediment trap and is probably more efficient in trapping sediment than the surrounding marshland.

SITE 11 SUDBURY P-8266

Framingham, Elm Street Bridge

QUADRANGLE: Framingham

DATE: 1 October 1973

TIME: 1400

WEATHER: Sunny and clear

DEPTH, MID-CHANNEL: 2.5 feet

TEMPERATURE PROFILE, MID-CHANNEL: 63.5 isothermal

D.O.: 8.4 mg/l

FLOW RATE: 0.4 f.p.s.

TURBIDITY: 2.0 J.T.U.

TRANSPARENCY: 5 feet (to bottom)

SUBSTRATE TYPES:

The deposit at this site was very poorly sorted. The predominant grain size is fine to medium sand. Deep surficial deposits of high-organic, fine-grain material were found in discrete patches. Our walking suspended numerous gastropod shells at the water surface. Clay balls were also observed in the bottom material.

LITTORAL AREA: Approximately 3-4 feet in width. sandy substrate.

OVERHANGING VEGETATION: None

FISH HABITAT:

The patches of dense, non-emergent vegetation provides good cover. A juvenile chain pickerel (Esox niger) was observed hiding among non-emergent vegetation.

OUTFALLS:

None noted, however, local residents indicated the presence of a textile mill outfall upstream of the site. Later investigations confirmed this.

SITE 11 CONTINUED

GENERAL AESTHETICS:

Apparently channelized with artificial fill on both banks, this river rates a poor.

POSSIBLE VALUE AS SLUDGE SITE:

Small "sludge" deposits were located at the site. The extent of these deposits is small, but the material is very likely "sludge". Another possible sludge site is located behind a nearby upstream dam. No sampling has been made there but it appears to be a likely spot.

SITE 12 ASSABET RIVER B-8261

Acton, Massachusetts Main Street Bridge

QUADRANGLE: Maynard

DATE: 26 September 1973

WEATHER: Bright and sunny

DEPTH, MID-CHANNEL: 3.5 feet

TEMPERATURE PROFILE, MID-CHANNEL: 59°F isothermal

D.O.: Midwater 10.2 mg/l

FLOW RATE: 0.7 f.p.s.

TURBIDITY: 0.9 J.T.U.

TRANSPARENCY: 3.5 feet (to bottom)

SUBSTRATE TYPES:

In high velocity current areas the substrate is a cobble armored, coarse sand type. At location of benthic sampling the substrate was highly variable. The dense mats of Elodea appeared to be the substrate regulator. With Elodea present the microenvironment was depositional in nature. The substrate in this environment was predominately fine grain, highly reduced material, associated with plant debris. With Elodea absent the micro-environment was erosional with a substrate of medium and fine sand. This characteristic of the site produced a marked irregularity in bottom topography. Approximately one mile upstream from the site sampled Potomogeton dominated the underwater vegetation.

OVERHANGING VEGETATION: None noted

FISH HABITAT:

The presence of dense mats of Elodea provides a good habitat for small fish.

OUTFALLS: None noted

LITTORAL AREA: Approximately 4 feet wide. River apparently channelized.

SITE 12 Continued

GENERAL AESTHETICS:

The channelized appearance of the site and the abandoned dam detract heavily from the clean character of the water. This site is classified as fair.

VALUE AS "SLUDGE" SITE:

Odonata	abundant
Trichopterians	abundant
Hirudinea	abundant

REMARKS:

Destruction of abandoned dam dewatered large area - post 1966.

SITE 13 ASSABET B-8270

Stow, Rt. 62 Bridge

QUADRANGLE: Hudson

DATE: 4 October 1973

TIME: 0900

WEATHER: Clear and sunny

DEPTH, MID-CHANNEL: 1.5 feet

TEMPERATURE PROFILE, MID-CHANNEL: 63.0° isothermal

D.O.: 7.5 mg/l

FLOW RATE: 1.5 f.p.s.

TURBIDITY: 1.0 J.T.U.

TRANSPARENCY: To bottom

SUBSTRATE:

The underlying substrate is fine and medium sand, but is overlain by a rock armor covered by Anacharis beds which entrap silt and other debris. The occurrence of this rocky armor and dense aquatic plant cover creates a very high habitat/niche diversity.

LITTORAL AREA:

At the site studied the stream is quite shallow and fast running, and no part is below light penetration depth.

OVERHANGING VEGETATION:

Minimal. There is some downstream from the site.

FISH HABITAT:

The dense aquatic vegetation is probably a good area for small fish. The fast water areas associated with deeper pools makes this stream a possible trout habitat.

SITE 13 Continued

OUTFALLS NOTED:

No outfalls were noted at this site. Foam was noted at the base of the upstream Farm Pond Dam. This foam became more pronounced over the duration of our sampling program. In addition the water had a reddish-brown cast.

GENERAL AESTHETICS:

Although the site is located in close proximity to a number of small fabricating plants, the general aesthetic appeal of the site rates a good.

POSSIBLE VALUE AS A "SLUDGE" SITE:

The farm pond up-stream is likely a depository of fine grain sediments and plant debris. However, it is not likely that this deposit could be considered "sludge" as the drainage basin of the Assabet does not drain a heavily industrialized area relative to other rivers in the Merrimack Basin.

APPENDIX B

Benthic macroinvertebrate Abundance and distribution,
September - October, 1973

STATION 1	TOTAL	MEAN/REPLICATE	% OF TOTAL
Nematoda[2]	1	<1	0.05
Bryozoan statoblasts[2]	6	1	0.28
Monopylephorus[3]	892	149	42.21
Nereis (arenaceodentata?)[3]	1094	182	51.77
Spiophanes sp.[3]	74	12	3.50
Prionospio sp.[3]	8	1	0.38
Scolecolepides sp.[3]	2	<1	0.09
Marinogammarus sp.[2]	1	<1	0.05
Crangon septemspinosa[2]	5	<1	0.24
Tandacea[2]	5	<1	0.24
Mya arenaria[2]	4	<1	0.19
Macoma balthica[2]	8	1	0.38
Mytilus edulis[2]	13	2	0.62

13 Species

2113 Individuals

[1] Intolerant

[2] Facultative

[3] Tolerant

STATION 2	TOTAL	MEAN/REPLICATE	% OF TOTAL
Nematoda[2]	19	3	0.23
Bryozoan statoblasts[2]	28	5	0.34
Pristina sp.[3]	2332	389	27.68
Limnodrilus sp.[3]	5020	837	59.59
Unidentified Oligochaete[3]	1	<1	0.01
Placobdella sp.[2]	6	1	0.07
Glossiphoniidae[3]	72	12	0.85
Piscicolidae[2]	5	<1	0.06
Gammarus sp.[2]	643	107	7.63
Tendipes sp.[3]	33	6	0.39
Tendipedidae[3]	95	16	1.13
Probezzia sp.[2]	29	5	0.34
Physa sp.[3]	4	<1	0.05
Sphaeriidae[3]	137	23	1.63

14 Species

8424 Individuals

STATION 3	TOTAL	MEAN/REPLICATE	% OF TOTAL
Dugesia tigrina[2]	5	<1	0.35
Nematoda[2]	63	10	4.47
Bryozoan statoblasts[2]	26	4	1.85
Stylaria sp.[3]	10	2	0.71
Pristina sp.[3]	216	36	15.33
Slavina sp.[3]	336	56	23.85
Limnodrilus sp.[3]	690	115	48.97
Nereis sp.[3]	1	<1	0.07
Helobdella stagnalis[3]	8	1	0.57
Glossiphonia complanata[3]	8	1	0.57
Glossiphoniidae[3]	19	3	1.35
Piscicolidae[2]	14	2	0.99
Tendipedidae[3]	13	2	0.92

14 Species

1409 Individuals

STATION 4	TOTAL	MEAN/REPLICATE	% OF TOTAL
Pristina sp.[3]	90	15	42.25
Limnodrilus sp.[3]	118	20	55.40
Tendipes sp.[3]	2	<1	0.94
Tendipedidae[3]	1	<1	0.47
Chaoborus sp.[2]	2	<1	0.94

5 Species

213 Individuals

STATION 5	TOTAL	MEAN/REPLICATE	% OF TOTAL
Pristina sp.[3]	42	7	31.11
Limnodrilus sp.[3]	88	15	65.19
Cheumatopsyche sp.[2]	2	<1	1.48
Tendipes sp.[3]	2	<1	1.48
Tendipedidae[3]	1	<1	0.74

5 Species

135 Individuals

STATION 6	TOTAL	MEAN/REPLICATE	% OF TOTAL
Nematoda[2]	1	<1	0.56
Stylaria sp.[3]	1	<1	0.56
Pristina sp.[3]	3	<1	1.69
Limnodrilus sp.[3]	46	8	25.99
Unidentified Oligochaete[3]	3	<1	1.69
Leptoceridae[2]	2	<1	1.13
Psychomyiid sp.[2]	1	<1	0.56
Psychomyiidae[2]	5	<1	2.82
Limnephilidae[2]	1	<1	0.56
Trichoptera[2]	1	<1	0.56
Polycentropus sp.[2]	6	1	3.39
Psephenus sp.[3]	1	<1	0.56
Dubiraphia sp.[3]	1	<1	0.56
Paraleptophlebia sp.[2]	3	<1	1.69
Baetidae sp.[1]	1	<1	0.56
Ephemera sp.[2]	22	4	12.46
Baetisca sp.[1]	1	<1	0.56
Veliidae[3]	1	<1	0.56
Helobdella stagnalis[3]	2	<1	1.13
Pentaneura sp.[1]	2	<1	1.13
Cryptochironomous sp.[3]	2	<1	1.13
Tendipedidae[3]	18	3	10.20
Probezzia sp.[2]	10	2	5.68
Alluaudomyia sp.[2]	1	<1	0.56
Tabanidae[2]	2	<1	1.13
Atherix sp.[2]	1	<1	0.56
Dipteran[2]	2	<1	1.13
Amnicola[1]	5	<1	2.82
Campelona decisum[1]	11	2	6.21
Sphaeriidae sp.[3]	21	4	11.86

30 Species

177 Individuals

STATION 6A	TOTAL	MEAN/REPLICATE	% OF TOTAL
Dugesia tigrina[2]	25	4	1.10
Nematoda[2]	8	1	0.35
Stylaria sp.[3]	4	<1	0.18
Pristina sp.[3]	15	2	0.66
Slavina sp.[3]	76	13	3.30
Limnodrilus sp.[3]	6	1	0.26
Cheumatopsyche sp.[2]	211	35	9.28
Hydropsychidae[2]	16	3	0.70
Leptoceridae[2]	16	3	0.70
Psychomyiidae[2]	131	22	5.76
Limnephilidae[2]	66	11	2.90
Hydroptilidae[2]	1	<1	0.04
Orthotrichia sp.[2]	5	<1	0.22
Trichopteran[2]	3	<1	0.13
Berosus sp.[3]	27	4	1.19
Psephenus sp.[3]	3	<1	0.13
Scirtes sp.[3]	2	<1	0.09
Promoresia sp.[3]	665	111	29.26
Elmidae[3]	21	4	0.92
Ephemerella sp.[2]	23	4	1.01
Paraleptophelibia sp.[2]	8	1	0.35
Stenonema sp.[1]	174	29	7.66
Baetis sp.[1]	6	1	0.26
Baetisca sp.[1]	3	<1	0.13
Ephemeroptera[2]	1	<1	0.04
Hyalella azteca[3]	2	<1	0.09
Gammarus sp.[2]	2	<1	0.09
Simulidae[2]	50	8	2.20
Tendipes sp.[3]	1	<1	0.09
Tendipedidae	653	109	28.73
Probezzia sp.[2]	1	<1	0.04
Alluaudomyia sp.[2]	1	<1	0.04
Atherix sp.[2]	30	5	1.32
Dipteran[2]	1	<1	0.09
Amnicola sp.	1	<1	0.04

Continued

STATION 6A (Continued)	TOTAL	MEAN/REPLICATE	% OF TOTAL
Sphaeriidae[3]	5	<1	0.22
Hetaerina sp.[2]	6	1	0.26
Boyeria sp.[2]	1	<1	0.04
Acroneura sp.[1]	1	<1	0.04
Isoperla sp.[1]	2	<1	0.09

40 Species

2273 Individuals

STATION 7	TOTAL	MEAN/REPLICATE	% OF TOTAL
Dugesia tigrina[2]	519	86	13.49
Nematoda[2]	7	1	0.18
Stylaria sp.[3]	1	<1	0.03
Pristina sp.[3]	32	5	0.83
Limnodrilus sp.[3]	183	30	4.79
Oligochaete[3]	1	<4	0.03
Cheumatopsyche sp.[2]	2857	476	74.27
Stenelmis sp.[1]	48	8	1.28
Notonectidae[3]	1	<1	0.03
Piscicolidae[2]	18	3	0.34
Asellus sp.[2]	77	13	2.00
Lirceus sp.[2]	3	<1	0.08
Gammarus sp.[2]	21	<1	0.55
Orconectes sp.[2]	1	<1	0.03
Pentaneura sp.[1]	1	<1	0.03
Tendipedidae[3]	34	6	0.88
Probezzia sp.[2]	1	<1	0.03
Amnicola sp.	14	2	0.39
Helisoma sp.	1	<1	0.03
Gastropoda	5	<1	0.13
Sphariidae	21	4	0.55
Lestes sp.	1	<1	0.03

22 Species

3847 Individuals

STATION 8	TOTAL	MEAN/REPLICATE	% OF TOTAL
Hydra sp.[2]	1	<1	0.18
Dugesia tigrina[2]	192	32	34.10
Nematoda[2]	2	<1	0.36
Bryozoan statoblast[2]	1	<1	0.18
Stylaria sp.[3]	3	<1	0.53
Pristina sp.[3]	163	27	28.92
Slavina sp.[3]	43	7	7.64
Limnodrilus sp.[3]	123	20	21.85
Oligochaeta[3]	2	<1	0.36
Elmidae[3]	1	<1	0.18
Helobdella stagnalis[3]	5	<1	0.89
Placobdella ornata[3]	4	<1	0.71
Glossiphoniidae[3]	3	<1	0.53
Piscicolidae[2]	2	<1	0.36
Hyaella azteca[3]	6	1	1.07
Cryptochironomous sp.[3]	1	<1	0.18
Tendipedidae[3]	4	<1	0.71
Amnicola sp.[1]	1	<1	0.18
Unionidae[2]	2	<1	0.36
Sphaeriidae[3]	3	<1	0.53
Lestes sp.[2]	1	<1	0.18

21 Species

563 Individuals

STATION 9	TOTAL	MEAN/REPLICATE	% OF TOTAL
Dugesia tigrina[2]	27	4	14.44
Nematoda [2]	3	<1	1.60
Bryozoan statoblasts[2]	1	<1	0.53
Stylaria sp.[3]	39	6	20.87
Pristina sp.[3]	7	1	3.75
Limnodrilus sp.[3]	44	7	23.53
Helobdella stagnalis[2]	2	<1	1.07
Glossiphoniidae[3]	3	<1	1.60
Cyclops sp.[2]	5	<1	2.67
Hyaella azteca [3]	46	8	24.60
Pentaneura sp.[1]	2	<1	1.07
Cryptochironomous sp.[3]	1	<1	0.53
Tendipedidae[3]	5	<1	2.67
Sphaeriidae[3]	2	<1	1.07

14 Species

187 Individuals

STATION 10	TOTAL	MEAN/REPLICATE	% OF TOTAL
Dugesia tigrina[2]	9	2	0.63
Nematoda[2]	1	<1	0.07
Bryozoan statoblasts[2]	1	<1	0.07
Stylaria sp.[3]	62	10	4.31
Pristina sp.[3]	46	8	3.20
Limnodrilus sp.[3]	106	18	7.34
Oligochaeta[3]	16	3	1.11
Cheumatopsyche sp.[2]	1	<1	0.07
Stenonema sp.[1]	1	<1	0.07
Helobdella stagnalis[3]	2	<1	0.14
Glossiphonia complanata[3]	1	<1	0.07
Placobdella ornata[2]	2	<1	0.14
Glossiphoniidae[3]	1	<1	0.07
Piscicolidae[2]	1	<1	0.07
Cladocera[2]	21	4	1.46
Hyalella azteca[3]	1128	188	78.39
Simulidae[2]	1	<1	0.07
Tendipes sp.[3]	4	<1	0.28
Tendipedidae[3]	19	3	1.32
Amnicola sp.[1]	6	1	0.42
Helisoma sp.[3]	3	<1	0.21
Physa sp.[3]	3	<1	0.21
Sphaeriidae[3]	4	<1	0.28

23 Species

1439 Individuals

STATION 11	TOTAL	MEAN/REPLICATE	% OF TOTAL
Dugesia tigrina[2]	497	83	1.46
Nematoda [2]	31	5	0.09
Bryozoan statoblasts[2]	53	9	0.16
Pristina sp.[3]	18,304	3,051	53.64
Limnodrilus sp.[3]	14,608	2,435	42.80
Helobdella stagnalis[3]	206	34	0.60
Glossiphonia complanata[3]	13	2	0.04
Glossiphoniidae[3]	146	24	0.43
Piscicolidae[2]	3	<1	0.008
Gammarus sp.[2]	3	<1	0.008
Tendipes sp.[3]	1	<1	0.002
Tendipedidae	4	<1	0.01
Lymnaea sp.[2]	94	16	0.28
Heliosoma sp.[3]	1	<1	0.002
Physa sp.[3]	48	8	0.14
Gastropoda[2]	16	3	0.05
Sphaeriidae sp.[3]	94	16	0.28

17 Species

34,122 Individuals

STATION 12	TOTAL	MEAN/REPLICATE	% OF TOTAL
Dugesia tigrina[2]	15	2	3.59
Nematoda sp.[2]	23	4	5.50
Bryozoan statoblasts[2]	1	<1	0.24
Pristina sp.[3]	175	29	41.88
Slavina sp.[3]	31	5	7.42
Limnodrilus sp.[3]	125	21	29.90
Unidentified oligochaete[3]	4	<1	0.96
Ephemerella sp.[2]	2	<1	0.48
Helobdella stagnalis[3]	3	<1	0.72
Placobdella ornata[2]	2	<1	0.48
Glossiphoniidae[3]	1	<1	0.24
Piscicolidae[2]	1	<1	0.24
Cyclops sp.[2]	1	<1	0.24
Hyalella azteca[3]	3	<1	0.72
Simulidae[2]	1	<1	0.24
Pentaneura sp.[1]	12	2	2.87
Tendipedidae[2]	4	<1	0.96
Helisoma sp.[3]	5	<1	1.20
Campeloma decisum[1]	1	<1	0.24
Gastropoda[2]	3	<1	0.72
Sphaeriidae[3]	5	<1	1.20

21 Species

418 Individuals

STATION 13	TOTAL	MEAN/REPLICATE	% OF TOTAL
Dugesia tigrina[2]	237	40	6.27
Nematoda[2]	1	<1	0.03
Bryozoan statoblasts[2]	1	<1	0.03
Stylaria sp.[3]	1	<1	0.03
Pristina sp.[3]	27	4	0.72
Slavina sp.[3]	47	8	1.24
Limnodrilus sp.[3]	78	13	2.07
Oligochaeta[3]	1	<1	0.03
Cheumatopsyche	3100	530	84.13
Stenelmis sp.[1]	1	<1	0.03
Ephemerella sp.[2]	11	2	0.29
Ephemera sp.[2]	1	<1	0.03
Placobdella sp.[2]	1	<1	0.03
Glossiphoniidae[3]	8	1	0.21
Piscicolidae[2]	3	<1	0.08
Asellus sp.[2]	10	2	0.26
Lirceus sp.[2]	9	2	0.24
Gammarus sp.[2]	9	2	0.24
Simulidae[2]	5	<1	0.13
Pentaneura sp.[1]	3	<1	0.08
Tendipedidae[3]	2	<1	0.05
Amnicola sp.[1]	108	18	2.85
Physa sp.[3]	3	<1	0.08
Gastropoda[2]	1	<1	0.03
Sphaeridae[3]	9	2	0.24
Ischnura sp.[2]	12	2	0.32
Climacia sp.[1]	8	1	0.21
Nymphula sp.[2]	2	<1	0.05

28 Species

3776 Individuals

APPENDIX B_1

SUMMARY OF WEATHER DATA
FOR FOUR WEATHER STATIONS IN EASTERN MASSACHUSETTS

SUMMARY OF WEATHER DATA AT
BOSTON (ALT. 15') AND MILTON BLUE HILL, MASSACHUSETTS (ALT. 629')
FROM 1968 - 1972

Precipitation, (in inches)

	BOSTON	BLUE HILL	$\bar{X}$
No. days with measurable precipitation (.01 inch or more)			
mean (years of record)	128 (21)	135 (87)	132
1968	118	117	118
1969	119	131	125
1970	125	124	124
1971	119	116	118
1972	154	157	156
Normal annual ppt. (1931 - 1960)	42.77	47.50	45.14
minimum ppt. in one month	0.35 (Sept.'57)	0.06 (Mar.'15)	0.20
maximum ppt. in one month (Aug. 1955)*	17.09	18.78	17.94
maximum ppt. in 24 hours (Aug. 1955)*	8.40	9.93	9.16
normal monthly ppt. in wettest month (Mar.; years '31-'60)	4.22	4.54	4.38
maximum ppt. in 24 hours (Mar.)	5.74	6.62	6.18
maximum monthly ppt. in March	11.00	10.96	10.98
normal ppt. in dryest month (July)	2.88	3.27	3.08
range of annual rainfall (1931-1972)	23.71 (1965) to 62.32 (1954)	26.96 (1965) to 65.51 (1972)	23.71 to 65.51

* Hurricane

Temperature, in degrees Fahrenheit

	BOSTON	BLUE HILL	$\bar{X}$
No. days with maximum <32°			
mean (years of record)	28 (8)	44 (87)	36
1968	35	49	42
1969	27	54	40
1970	40	60	50
1971	23	40	32
1972	24	43	34
No. days with minimum <32°			
mean (years of record)	103 (8)	132 (87)	118
1968	94	119	106
1969	104	134	119
1970	104	127	116
1971	116	140	128
1972	107	143	125
Normal temperature averages			
annual	59.0	57.3	58.2
coldest month	29.9	27.0	28.4
warmest month	73.7	70.9	72.3
Temperature extremes			
monthly average ('31-'72)	17.5 to 76.2	13.5 to 74.9	13.5 to 76.2
absolute (years of record)	-4 to 98 (8)	-21 to 101 (87)	-21 to 101
Average date of first freezing temperature	7 Nov.	21 Oct.	30 Oct.
Average date of last freezing temperature	8 Apr.	26 Apr.	17 Apr.
Freeze free period (days)	213	178	196

Evapotranspiration

	BOSTON	BLUE HILL	$\bar{X}$
Percent possible sunshine			
yearly average (years of record)	59 (37)	52 (86)	56
average for month of maximum sunshine (July/Aug.)	66	58	62
average for month of minimum sunshine (Dec./Jan.)	51	45	48
monthly extremes	28-86	30-71	28-86
Average daily solar radiation (langleys)			
yearly average (years of record	312 (21)	329 (38)	
average for dullest month (Dec.)	120	134	127
average for brightest month (June)	503	518	510
Relative humidity			
yearly average (years of record)			
0100 hours maximum humidity	72 (8)	79 (22)	
1300 hours minimum humidity	59 (8)	58 (33)	
monthly maximum nighttime	80 (Sept.)	87 (Aug.)	
monthly minimum nighttime	64 (Feb.)	72 (Jan./Feb.)	
monthly maximum daytime	65 (Nov.)	62 (Nov., Dec., Jan.)	
monthly minimum daytime	54 (Apr./ July)	51 (Apr.)	
Wind			
prevailing direction (years of record)	SW (15)	NW (56)	
months in which prevailing direction is SW	Mar. through Nov.	July through Sept.	
months in which prevailing direction is NW	Dec. through Apr.	Oct. & Feb. through Apr.	

	BOSTON	BLUE HILL	$\bar{X}$
months in which prevailing direction is W	None	Nov. through Jan.	
months in which prevailing direction is S	None	May & June	
mean annual speed (m.p.h.)	12.9	15.4	
mean speed lightest month (Aug.)	11.2	12.6	
mean speed heaviest months (Jan. - Mar.)	14.5	17.4	
highest wind, winter storms (m.p.h.)	58	68	

Snowcover

Average no. days with cover (years of record)			
cover is usually intermittent	(37)	63 (87)	
Snow season	Dec. to Mar.	Nov. to Apr.	
No. days with 1 inch or more snowfall	11	16	
Mean yearly snow fall (inches)	42.8	60.7	
Maximum monthly snow fall	41.3 (Feb.'69)	56.3 (Jan.'48)	
Maximum snowfall, 24 hours	19.4 (feb.'58)	27.2 (Mar.'60)	
Percent of ppt. occurring as snow		∿14	

SUMMARY OF WEATHER DATA AT WORCESTER, MASSACHUSETTS (ALT. 986') FROM 1968 - 1972

Precipitation (in inches)

No. days with measurable precipitation (.01 inch or more)	
mean (17 years of record)	129
1968	123
1969	135
1970	119
1971	110
1972	148
Normal annual ppt. (1931-1960)	45.41
minimum ppt. in one month	0.83 (Sept.'57)
maximum ppt. in one month	10.40 (Nov.'72)
maximum ppt. in 24 hours	4.79 (Sept.'60)
normal ppt. in wettest months (August/ November)	4.24/4.26
normal ppt. in dryest month (Feb.)	2.92
range of annual rainfall (1933-1972)	27.92 (1941) to 71.66 (1972)

Temperature

No. days with maximum temperature <32°F	
mean (17 years of record)	56
1968	63
1969	71
1970	72
1971	52
1972	57

No. days with minimum temperature <32°F

mean	148
1968	134
1969	144
1970	150
1971	154
1972	163

Normal temperature averages (°F.)

annual	46.8
coldest month	24.0
warmest month	69.8

Temperature extremes (°F)

monthly average ('31-'72)	14.4 to 74.3
absolute (72 years of record)	-24 to 102

	Exposed	Low Lying
Average date of first freezing temperature	15 Oct.	3 Oct.
Average date of last freezing temperature	26 Apr.	7 May
Freeze free period (days)	172	149

Evapotranspiration

Relative humidity

yearly average (17 years of record)

0100 hours maximum humidity	75
1300 hours minimum humidity	56
monthly maximum nighttime	82 (Sept.)
monthly minimum nighttime	68 (Apr.)
monthly maximum daytime	64 (Dec.)
monthly minimum daytime	47 (May)

Wind

Prevailing direction (8 years of record)	W
months in which prevailing direction is SW	May through Sept.
months in which prevailing direction is WSW	Oct. through Jan.
months in which prevailing direction is W	May & April
months in which prevailing direction is WNW	Feb.

mean annual speed (m.p.h., 17 years of record)	10.5
mean speed, lightest month (Aug.)	8.6
mean speed, heaviest month (Jan.)	12.7
highest wind, winter storms (m.p.h.)	76

Snow cover

No. days with 1 inch or more snowfall (17 year average)	19
mean yearly snowfall (inches)	79.1
maximum monthly snowfall (inches)	45.2 (Feb. '62)
maximum snowfall, 24 hours (inches)	24.0 (Feb. '62)

SUMMARY OF WEATHER DATA AT
NANTUCKET, MASSACHUSETTS (ALT. 43')
FROM 1968 - 1969

Precipitation (inches)

No. days with measurable precipitation (.01 inch or more)	
mean (23 years of record)	125
1968	123
1969	123
Normal annual ppt. (1931 - 1960)	43.66
minimum ppt. in one month	0.01 (Jun.'49)
maximum ppt. in one month	2.92 (Aug.'46)
maximum ppt. in 24 hours	6.53 (May'67)
normal ppt. in wettest months (March/November)	4.54/4.05
normal ppt. in dryest month (July)	2.71
range of annual rainfall (1931 - 1969)	25.31 (1965 to 60.39 (1958)

Temperature

No. days with maximum temperature <32°F	
mean (4 years of record)	16
1968	27
1969	7
No. days with minimum temperature <32°F	
mean (4 years of record)	108
1968	97
1969	96
Normal temperature averages (°F)	
annual	49.5
coldest month	31.4
warmest month	68.0

Temperatures extremes (°F)

monthly average	26.7 to 71.8
absolute (72 years of record)	-6 to 95

Evapotranspiration

Percent possible sunshine

yearly average (23 years of record)	55
average for month of maximum sunshine (June)	61
average for month of minimum sunshine (Dec.)	41

Relative Humidity

Yearly average (4 years of record)

0100 hours maximum humidity	85
1300 hours minimum humidity	70
Monthly maximum nighttime	97 (June)
Monthly minimum nighttime	75 (Dec./Feb.)
Monthly maximum daytime	78 (June)
Monthly minimum daytime	65 (Apr.)

Wind

Prevailing direction (14 years of record)	SW
months in which prevailing direction is SW	May through October
months in which prevailing direction is NW	November, January & March
months in which prevailing direction is WNW	February & December
months in which prevailing direction is WSW	April
mean annual speed (23 years of record)	13.2 m.p.h.
mean speed, lightest month (August)	10.9 m.p.h.
mean speed, heaviest month (February & March)	15.2 m.p.h.
Highest wind, winter storms	73 m.p.h.

Snow cover

Av. no. days with cover	intermittent, few days at a time

No. days with 1 inch or more snowfall (23 year average)	8	
mean yearly snow fall (inches)	34.8	
maximum monthly snow fall (inches)	40.2	(Mar.'60)
maximum snowfall, 24 hours (inches)	20.1	(Feb.'52)

APPENDIX C.

PHYSIOGRAPHIC AND EDAPHIC DESCRIPTIONS OF TWENTY TERRESTRIAL SITES IN NORTHEASTERN MASSACHUSETTS AND CAPE COD

The major physiographic features and dominant soil series of each of the twenty sites is presented below. Substantial variability exists among the sites in regard to these characteristics and consequently each site will be discussed separately.

SITE 1

The principal physiographic feature consists of a rather large hill located in the northeast portion of the site with a maximum elevation of 280 feet msl. High lands in the southwestern portion are the northwesterly extensions of Strawberry Hill. There are some swamp areas located along Nashoba Brook, along Spencer Brook and in the southern most portion (northeast of Strawberry Hill). There is a small impoundment at the head of Nashoba Brook to the northwest of the site.

The higher lands are dominated by Paxton extremely stony fine sandy loams. Slopes are generally less than 8% but are 8 - 15% in the southern portions. Small areas in the extreme southern and western sectors have steeper slopes (15 - 35%). Woodbridge very stony fine sandy loam is the next most dominant series which lies north, west and south of the Paxton deposites. Slopes on the Woodbridge series generally range from 3 - 8% but hills with 0 - 3% and 8 - 15% are present. Along the northern and western perimeter, Hinckley loamy sands (slopes 3 - 15%) are to be found. Shallow and deep deposits of muck as well as Ridbury very stony and extremely stony sandy loams surround the impoundment. The swampy areas within the site are composed of deep muck. Small areas of Hollis extremely rocky fine sandy loam (most slopes 3 - 15%; some up to 45%) and Whitman very stony and extremely stony loams (slopes 0 - 15%) are scattered throughout the site.

SITE 2

Site 2 consists of two major hills. The slopes in the western areas are steeper and higher with a maximum elevation of more than 730' msl. The soil on these slopes is composed of Hollis extremely rocky fine sandy loams. Slopes at the higher elevations range from 3 - 15% whereas the lower slopes vary from 15 - 35%. The eastern hill (maximum elevation of 667' msl) has more gentle relief and is primarily composed of Paxton very stony fine sandy loam on slopes of

8 - 15% at the lower elevations and 3 - 8% near the top. Most of the Hollis and Paxton soils are forested but small areas in the southwest and southeast are planted to an apple orchard. There is a small swampy area in the south-central portion of this site which is composed of Whitman very stony and extremely stony loams (slopes 3 - 8%).

SITE 3

Site 3 has considerable relief. The primary topographic feature is Long Hill which occupies the southwestern portion. Slopes near the top vary from 3 - 8% but those of lower elevations to the east and northwest vary from 15 - 35%. Slopes in the northern sections are gentle at the higher elevations and steeper farther downhill. Maximum elevations at this site are approximately 440 feet. There are several low swampy areas present; one is found in the southeast along a small creek, four other small areas are located in the central and northern sections.

The major upland soils are Woodbridge extremely stony fine sandy loams and Paxton extremely stony fine sandy loams which have developed on glacial till. Hollis extremely rocky fine sandy loams, which have also formed in thin deposits of glacial till, are present on this site. The poorly drained swampy areas are composed of muck and Whitman very stony and extremely stony loam. At the northern edge of the site Hinckley loamy sands, Sudbury fine sandy loam and Walpole fine sandy loams are found.

SITE 4

The most prominent topographic feature is Fairhaven Hill which has a maximum elevation of about 340' msl. The slopes of this hill are moderate (8 - 15%) to the north but are quite steep (15 - 35%) to the south and west. Prominent bedrock outcropping is located on the southern and southwestern slopes. There is a rather extensive, relatively flat-topped terrace-like formation to the east and south of Fairhaven Hill. This formation has 3 - 8% slopes at the top and 10 - 20% slopes along the edges. The northeastern point of this site is located within Walden Pond State Reservation.

The major soil series of the upland sections of this site are Windsor loamy sands which occupy the northern and eastern areas. The Windsor loamy sands occupy approximately 400 acres and about

75% of all Windsor soils are on slopes ranging from 0 - 15%. Paxton very stony fine sandy loams occupy most of the more gentle slopes of Fairhaven Hill and extend to the northwest section of the site. Hollis very rocky fine sandy loams are found on the steeper slopes of the Hill. The dominant soils on the terrace-like formation are Agawam fine sandy loams.

SITE 5

The northern portion of the site consists of rolling hills with moderate slopes (generally less than 8%) except along terraced areas where slopes up to 20% are found. The southern portion is dominated by Buttricks Hill which is over 200' in elevation with slopes ranging between 15 - 20%. A terrace-like formation lies to the north of Buttericks Hill with moderate slopes of 8 - 15%.

The primary soil series found on this site (approx. 75% of area) is Windsor loamy sand which is on slopes of 0 - 15%. The northern tip of the site is composed of Hinckley loamy sands most of which is on slopes of 15 - 35%. There are two small areas of muck in the northwest and southeast sections. Two formations of Hollis very rocky fine sandy loams are located in the center of the area. Small amounts of Paxton very stony fine sandy loam is found in the west and south. An area of Deerfield loamy sand is situated on the southwest perimeter of the site. A very small area of Agawam fine sandy loam is located in the south and an area of Ridgebury very stony and extremely stony fine sandy loam in the west.

SITE 6

The major topographic features are Marsh Hill to the west with maximum elevation of 282' msl and Burns Hill to the northeast with a maximum elevation of about 290 feet. The slopes on these hills are variable but generally are less than 15% except for sections to the south and southwest of Marsh Hill and northwest of Burns Hill (slopes 15 - 35%). Slopes on the northwest slopes and top of Marsh Hill vary from 2 - 4%.

A large portion of the western half of this site is composed of the Woodbridge series. The most dominant is Woodbridge fine sandy loam. Woodbridge very stony and extremely stony fine sandy loams are situated along the western perimeter. Woodbridge very stony fine

sandy loam lies along the south central portion. Adjacent to the Woodbridge soils in the far western portion and along south central area are situated soils of the Paxton series. The most abundant is Paxton very stony fine sandy loam but there is an area of extremely stony fine sandy loam at the center of the site. Small areas of Ridgebury very stony and extremely stony fine sandy loams are scattered throughout the site. Soils of the Essex series are situated in the south central and eastern portions of the area. The most abundant is very stony fine sandy loam but small areas of fine sandy loam and extremely stony fine sandy loam are also present. A swampy area of primarily deep muck exists at the northeastern portion of the site. The major series in the eastern portion of the site is Scituate. The most abundant is extremely stony fine sandy loam. Next in abundance is fine sandy loam and the least abundant is very stony fine sandy loam.

SITE 7

The northern portion of this site is called Kimball Hill with a maximum elevation of about 200 feet msl. Slopes near the top of the hill range from 3 - 8% while those farther down range from 8 - 15%; some of the steeper slopes of the east side toward the Merrimack River are between 15 - 35%. The major feature at the southern portion of the site is a hill with a maximum elevation of 192 feet msl. Slopes on the west side of the hill range from 3 - 8% and those on the east, north and south range from 15 - 35%. The area to the east of East Broadway Street is quite steep eventually joining the fairly level river flood plain which occupies the extreme eastern perimeter and central portion of the site.

The major soil series on Kimball Hill is Paxton. Paxton fine sandy loams, Paxton very and extremely strong fine sandy loams are present in about equal proportions. Two small areas of Woodbridge fine sandy loams lie to the east and west of the hill. The principal soil along the river is Winooski very fine sandy loam. There is a small amount of Hadley very fine sandy loam near the river at the central portion of the site. The principle soil in the mid and southern section of the site is Windsor loamy sands. About half of this soil lies on slopes between 0 - 8% and the other 50% on hills with slopes as steep as 25 to 35%. The large hill in the south is composed of Paxton very and extremely stony fine sandy loams.

SITE 8

This site consists of terraced uplands at elevations of approximately 550' msl in the norther portion and 600' msl in the southern section. The boundaries of the terraces are characterized by steep slopes with undulating kettle and kame topography between them. A small body of water is situated in the north central portion which is surrounded by peat. A marsh lies between River Street and Malden Hill. The major soil is Merrimac sandy loam which is distributed throughout the site. There are small amounts of Merrimac fine sandy loams. Most of the slopes are 0 - 8% but a good percentage is 8 - 25%. There are considerable amounts of Hinckley loamy sands throughout this site primarily on the steeper slopes (15 - 35%) although some is on 0 - 15% slopes. Next in abundance is Windsor loamy sands located on 8 - 15% slopes in the west central portion. An area of Sutton extremely stony fine sandy loam lies in the east central portion of the site on 3 - 8% slopes. Small amounts of Hinckley very stony loamy sand and Agawam fine sandy loams are found in northwestern and central portions of the site. The area surrounding the pond is composed of peat and Whitman very stony and extremely stony loams.

SITE 9

This site includes two hills, Highlands Hill (elevation 296' msl) and twin-peaked Red Oak Hill (elevation 315' msl). A swamp area of considerable size lies to the south of this site. Gentle slopes of up to 35% are found on the south sides of both hills.

The soil series within this area form a complex arrangement. Several series are abundant but no one in particular predominates. Included are Acton very stony fine sandy loams and fine sandy loams, Sutton fine sandy loams and very stony fine sandy loam, Paxton fine sandy loam and very stony fine sandy loams and Canton fine sandy loam and very stony fine sandy loam. The Paxton soils are found on Red Oak Hill with slopes ranging from 8 - 25%. The area surrounding this hill is composed of Acton soils on slopes of 0 - 8% to steeper slopes (8 - 25%). Canton soils are found on Highlands Hill on slopes of 3 - 15%. Surrounding this hill on slopes of 0 - 15% lies the Sutton soils. Whitman loams and very-extremely stony loams are found in the drainage area between these two hills. The western area is composed of mixtures of Sutton fine sandy loams, Acton fine sandy loams and very stony fine sandy loams and Ridgebury very

and extremely stony fine sandy loams along with small areas of Canton very stony fine sandy loams, Merrimac sandy and fine sandy loams, Whitman loams and Woodbridge very stony fine sandy loams.

SITE 10

This site has a rather gentle relief. Nearly 80% of the slopes have less than a 10% grade. Maximum elevation is about 320 feet msl. Approximately 20% of the area is composed of farmland which is situated along Great Road and Beaver Brook Road. This land is nearly flat and is cultivated with corn and vegetable crops (along Great Road) and fields (along Beaver Brook Road). Forge Pond lies to the North of the site and to the east there exists a swampy area adjacent to Beaver Brook.

The primary soils in the central elevated portions are Paxton very stony and extremely stony fine sandy loams on slopes of about 4 - 5 per cent. The Paxton soils extend to the mid-section of the western perimeter. A zone of Woodbridge very stony and extremely stony fine sandy loams surrounds the Paxton soils to the north, east and south (slopes 3 - 8%). A small area of Canton very stony fine sandy loam is situated in the south central part of the site. Hinckley loamy sands (3 - 8% slopes) are located along the eastern and southeastern perimeter and in the north section of the site. Small areas of Sudbury fine sandy loams are located adjacent to the Hinckley soils. Windsor loamy sands predominate in the northwest "neck". There is an area of Hollis very rocky fine sandy loam in the southwest section. An area of Scarboro fine sandy loam is found in the north on 0 - 3% slopes.

SITE 11

This area is an elongated flat topped terrace on the west bank of the Nashua River. The flat topped area drops off rather steeply to the river flood plain.

The major soil types are Hinckley loamy sands and Merrimack sandy loams.

SITE 12

This site consists of somewhat knobby or hummocky terrain with gentle to flat slopes. Certain sections, especially along the Merrimack River, have steeper slopes which approach a maximum of 20-25%. However, these areas are very limited and most slopes within the site are less than 8%. A small spring-fed brook flows through the western part of the site into a pond and then discharges into the Merrimack River.

Merrimack fine sandy loam is the dominant soil type in the mid section of the site with small areas of Merrimack sandy loams and Sudbury fine sandy loams interspersed throughout. An area of Paxton fine sandy loam exists on a small hill in the northwest section. The northern portion is dominated by Elmwood fine sandy loam and Hinckley loamy sands with some Swanton fine sandy loam. The southern section is dominated by Hollis extremely rocky fine sandy loam with some Hinckley loamy sands present.

SITE 13

This is a gently sloping area with slopes primarily from west to east at about a 2-3% grade. Two small brooks are found on this site, one in the north (man-made) and the other at the southern tip.

The major soil type on this site is Woodbridge very stony fine sandy loam and it occupies most of the initial area. To the north and east are found deposits of Ridgebury fine sandy loams. To the south and west are found Paxton fine sandy loam with a thin strip of Whitman very stony and extremely stony loam in the center. The northern perimeter of the site is dominated by Woodbridge fine sandy loam.

SITE 14

This area is nearly flat which lies between the Unkety Brook drainage to the northeast and a portion of the Nashua River flood plain to the west. Slopes are generally less than 1 per cent although slopes of 3% are found near Unkety Brook. A small tributary to this brook arises at the site center and flows northeast. A small pond is found at the southwest corner.

The dominant soils on this site are Hinckley loamy sands in the west, central and southern area; and Windsor loamy sands in the southeast and northern sections. An area of Au Gres loamy sands exist along the small northeasterly flowing brook.

SITE 15

This site consists of a large twin-peaked hill with maximum elevations of 551' and 557' msl. Slopes vary from 12% at the higher elevations at the center of the site to as low as 3% at some of the lower elevations and in the northwestern section. Marshy areas adjacent to tributaries of Wekepeke Brook lie to the southwest and northeast of the site.

The predominate soils in this site are Paxton extremely stony fine sandy loam in the eastern half (slopes 8 - 15%) and Woodbridge extremely fine stony sandy loam in the western half (slopes 3 - 8%). Small amounts of Ridgebury (slopes 3 - 8%) very stony and extremely stony fine sandy loams are found in the south, Whitman very stony and extremely stony loams (slopes 0 - 3%) in the south and north and Paxton very stony fine sandy loam in the east (slopes 3 - 15%).

SITE 16

This site consists of a long ridge running in a northeast-southwest direction. The southwest portion is Reeves Hill at an elevation of 406 feel msl. The maximum relief is about 200 feet. Slopes range from 8 - 10% to as much as 25% especially along Reeves Hill. An extensive marsh area lies to the south and several small lakes to the northeast.

The major series in the northern lobe of this site is Paxton. Paxton fine sandy loams (slopes 0 - 25%) are most abundant followed

by Paxton very stony fine sandy loams (slopes 8 - 25%) and finally Paxton extremely stony fine sandy loams (slopes 15 - 35%). The northern most tip is composed of about equal amounts of Narragansett very stony very fine sandy loam (slopes 3 - 15%) and Enfield very fine sandy loam (slopes 3 - 8%). Other soils found in small areas in the north are Woodbridge very stony fine sandy loam and Deerfield loamy sands. The central portion of the site is composed mostly of Narragansett (slopes 3 - 8%) along with Sutton very stony fine sandy loam and Hollis very rocky fine sandy loam. The southwestern section is composed primarily of Hollis very rocky and extremely rocky fine sandy loam (slopes 3 - 25%) but there is some Narragansett and a very small amount of Whitman very and extremely stony loams. The southeastern lobe of this site is composed of mostly Merrimac fine sandy loam (slopes 0 - 8%) with some Hollis, Whitman and Narragansett.

SITE 17

The most prominent feature of the site is Long Hill with moderate slopes at the higher elevations (8 - 15%) and maximum slopes of 20 - 25% at lower levels and along the western edge. A small stream flows through the site in an easterly direction to the Merrimack River. The lower elevations have slopes ranging from 3 - 8%.

The soil patterns on this site are complex but the dominant types are Charlton fine sandy loam (slopes mostly 3 - 15% but some 15 - 25%) and Sutton fine sandy loam (slopes 3 - 15%) and Sutton very stony fine sandy loam (slopes 3 - 25%). These soils are interspersed throughout the entire area. Areas of Whitman loams (slopes 0 - 8%) are situated in the southeastern portion. Along the creek there are deposits of Ridgebury (slopes 0 - 8%) fine sandy loam. The area along the northern perimeter has small areas of Hollis fine sandy loam, Buxton silt loam, Ningret fine sandy loam, silty subsoil variant, Scantic silt loam, Elmwood fine sandy loam and Swanton fine sandy loam. The western perimeter has small areas of Saco silt loam, Agawan fine sandy loam, Winooski very fine sandy loam and Limerick silt loam.

SITE 18

This site has ridge and valley terrain with uplands at 110 foot elevations and valleys at 40 feet of elvation. Slopes vary from gentle at the higher elevations to very steep along Prince Valley,

Country and Pamet Point Roads as well as Lombard and Paradise Hollows. Two bodies of water, Round Pond and the much larger Ryder Pond are found along the southeast perimeter. Marsh areas associated with Round Brook and the Herring River are found to the west and south respectively.

Detailed soils maps are not available for this site but the probable soils include: Agawam fine sandy loams, Carver coarse sand, peat, Saugatuck sands and Windsor loamy sands.

SITE 19

This site is relatively flat with scattered kettle holes and a general elevation between 190 feet in the north to 150 feet in the south. There is a major drainage area in the southeast section leading into Snake Pond.

Detailed soils maps are not available for this site but the probable soils include: Dukes coarse sand, Carver coarse sand, Saugatuck sand and peat.

SITE 20

This site is an elongate, relatively flat-topped glacial outwash plain lying above marshy areas on the flood plains of Templeton Brook to the west and Hubbardston Brook to the east. The northern section consists of a small hill (maximum elevation >1000' msl) which overlooks the upper Otter River drainage. In the south, slopes on top range from 0 - 8% and those leading to the flood plains range from 15 - 35%. About 20% of this site is State Forest land.

A detailed soils map is not available for this area but probable soils include primarily Hinckley loamy sand with some Merrimack sandy loam.

APPENDIX D

GROUNDWATER QUALITY DATA FOR VARIOUS TOWNS IN NORTHEASTERN MASSACHUSETTS AND CAPE COD

NORTHERN ESSEX COUNTY REGION

PARAMETER		GROVELAND	GEORGETOWN	ROWLEY	NEWBURY	MERRIMAC	AMESBURY	SALISBURY	NEWBURYPORT
pH	1971	6.7	6.4	7.1		6.3	6.7	7.0	6.7
	1972	6.7	6.3	6.9	7.6	6.1	6.5	6.7	6.5
Alkalinity	1971	47.0	31.0	57.0		22.0	43.0	40.0	36.0
(ppm)	1972	46.0	40.0	78.0	138.0	24.0	35.0	47.0	25.0
Hardness	1971	71.0	62.0	102.0		49.0	55.0	76.0	70.0
(ppm)	1972	66.0	58.0	98.0	134.0	54.0	45.0	84.0	53.0
Iron	1971	0.20	0.14	0.09		1.60	2.80	0.42	0.01
(ppm)	1972	0.32	0.26	0.09	0.33	1.50	4.80	0.59	0.01
Manganese	1971	0.01	0.06	0.00		0.48	0.27	0.02	0.00
(ppm)	1972	0.06	0.20	0.01	0.01	0.64	0.25	0.08	0.03
Ammonia N	1971	0.00	0.02	0.00		0.06	0.23	<0.01	0.00
(ppm)	1972	0.00	0.02	0.00	0.00	0.08	0.03	0.00	0.00
Nitrate N	1971	0.4	0.04	1.0		0.4	0.0	0.03	1.0
(ppm)	1972	0.4	0.4	0.8	1.2	0.4	0.0	0.4	1.1
Chlorides	1971	12.0	15.0	79.0		25.0	18.0	40.0	30.0
(ppm)	1972	12.0	15.0	58.0	21.0	35.0	15.0	47.0	29.0
Sodium	1971	7.0	8.0	26.0		13.0	8.0	17.0	10.0
(ppm)	1972	7.0	13.0	26.0	15.0	16.0	9.0	18.0	11.0
Potassium (ppm) (ppm)	1972	1.4	1.6	2.0	2.8	2.2	1.5	2.5	1.9
Silica (ppm)	1972	16.0	16.0	13.0	14.0	15.0	31.0	15.0	16.0
Sulfate (ppm)	1972	26.0	21.0	14.0	23.0	27.0	14.0	43.0	13.0
Cond. $\left(\frac{\text{micromhos}}{\text{cm.}}\right)$	1972	175.0	165.0	330.0	340.0	192.0	145.0	300.0	169.0

MIDDLESEX - WORCESTER COUNTY AREA

PARAMETER		ANDOVER	DRACUT	TEWKSBURY	TEMPLETON	CHELMSFORD	WESTFORD	LOWELL
pH	1971	7.4	6.6	6.4	6.3	6.4	6.5	6.8
	1972	8.8	6.4	6.2	6.2	6.2	6.4	6.7
Alkalinity (ppm)	1971	40.0	24.0	21.0	12.0	21.0	23.0	37.0
	1972	67.0	20.0	20.0	14.0	27.0	18.0	86.0
Hardness (ppm)	1971	52.0	36.0	50.0	19.0	66.0	34.0	64.0
	1972	49.0	33.0	57.0	26.0	63.0	33.0	126.0
Iron (ppm)	1971	0.06	0.02	0.44	0.08	0.66	0.23	0.22
	1972	0.01	0.03	0.38	0.48	0.94	0.04	0.01
Manganese (ppm)	1971	0.04	0.71	0.32	0.02	0.18	0.06	0.14
	1972	0.04	1.80	0.33	0.06	0.22	0.12	0.00
Ammonia N (ppm)	1971	<0.01	0.06	0.02	0.00	0.03	<0.01	0.18
	1972	0.00	0.27	0.01	0.01	0.06	<0.01	0.01
Nitrate N (ppm)	1971	1.0	0.7	1.4	0.04	1.6	0.6	1.3
	1972	1.3	0.8	1.8	0.04	1.6	0.6	2.3
Chlorides (ppm)	1971	25.0	15.0	28.0	15.0	58.0	20.0	20.0
	1972	33.0	23.0	37.0	21.0	58.0	24.0	29.0
Sodium (ppm)	1971	19.0	8.0	15.0	9.0	24.0	8.0	12.0
	1972	43.0	12.0	22.0	12.0	28.0	10.0	11.0
Potassium (ppm)	1972	2.3	2.0	2.5	1.4	3.0	1.7	3.1
Silica (ppm)	1972	14.0	11.0	17.0	14.0	16.0	16.0	17.0
Sulfate (ppm)	1972	17.0	8.0	33.0	7.0	22.0	4.0	29.0
Cond. $\frac{(\text{Micromhos})}{\text{cm}}$	1972	277.0	145.0	228.0	119.0	279.0	126.0	290.0

(Continued)

(CONTINUED)

PARAMETER		DUNSTABLE	PEPPERELL	GARDNER	WESTMINSTER	LUNENBURG	GROTON	LITTLETON
pH	1971	6.8	6.6	6.3	6.7	6.5	6.6	6.8
	1972	6.2		5.7	6.0	6.2	6.4	5.8
Alkalinity (ppm)	1971	26.0	13.0	7.0	14.0	17.0	34.0	24.0
	1972	27.0		8.0	7.0	15.0	38.0	10.0
Hardness (ppm)	1971	39.0	18.0	28.0	7.0	45.0	47.0	71.0
	1972	37.0		20.0	5.0	44.0	48.0	39.0
Iron (ppm)	1971	0.12	0.05	0.16	0.02	0.03	0.10	0.18
	1972	0.40		0.13	0.26	0.05	0.23	0.02
Manganese (ppm)	1971	0.81	0.00	0.05	0.01	0.00	0.32	0.03
	1972	0.31		0.05	0.02	0.04	0.26	0.12
Ammonia N (ppm)	1971	0.05	0.01	0.00	0.00	0.01	<0.01	0.02
	1972	0.01		0.00	0.00	0.00	0.02	0.00
Nitrate N (ppm)	1971	0.5	0.3	0.1	0.00	0.3	1.1	1.0
	1972	0.7		0.1	0.00	0.4	0.2	0.7
Chlorides (ppm)	1971	28.0	6.0	9.0	2.0	34.0	13.0	46.0
	1972	35.0		7.0	2.0	34.0	12.0	39.0
Sodium (ppm)	1971	14.0	4.0	5.0	2.0	12.0	6.0	----
	1972	18.0		5.0	2.0	16.0	5.0	15.0
Potassium (ppm)	1972	2.9		0.6	0.9	2.9	1.8	2.3
Silica (ppm)	1972	12.0		13.0	8.0	14.0	13.0	13.0
Sulfate (ppm)	1972	5.0		12.0	0.00	18.0	12.0	21.0
Cond. $\frac{\text{(Micromhos)}}{\text{cm}}$	1972	163.0		75.0	32.0	170.0	120.0	167.0

(Continued)

(CONTINUED)

PARAMETER		HARVARD	WEST BOYLSTON	CONCORD	WAYLAND	ACTON	BEDFORD	LEOMINSTER
pH	1971	6.7	6.4	7.0	6.6	6.2	6.2	6.9
	1972	6.5	6.2	7.0	6.6	6.2	6.2	6.5
Alkalinity (ppm)	1971	36.0	17.0	33.0	48.0	18.0	25.0	15.0
	1972	42.0	17.0	25.0	48.0	22.0	25.0	11.0
Hardness (ppm)	1971	70.0	42.0	45.0	93.0	49.0	57.0	24.0
	1972	60.0	38.0	27.0	90.0	49.0	55.0	16.0
Iron (ppm)	1971	0.01	0.06	0.04	0.06	0.07	0.08	0.01
	1972	0.03	0.06	0.23	0.05	0.07	0.11	0.00
Manganese (ppm)	1971	0.00	0.02	0.02	0.10	0.13	0.19	0.00
	1972	<0.01	0.02	<0.01	0.14	0.14	0.30	0.00
Ammonia N (ppm)	1971	0.01	<0.01	0.00	0.02	0.03	0.09	0.01
	1972	0.00	<0.01	<0.01	<0.01	0.15	0.08	0.00
Nitrate N (ppm)	1971	2.1	1.0	1.4	4.5	1.4	0.9	0.5
	1972	0.8	1.1	0.5	2.9	0.8	1.0	0.3
Chlorides (ppm)	1971	38.0	25.0	14.0	18.0	38.0	55.0	4.0
	1972	23.0	26.0	10.0	29.0	32.0	47.0	5.0
Sodium (ppm)	1971	15.0	12.0	14.0	10.0	18.0	27.0	4.0
	1972	11.0	12.0	10.0	14.0	18.0	31.0	3.0
Potassium (ppm)	1972	1.4	1.7	1.5	2.0	2.3	2.2	0.8
Silica (ppm)	1972	12.0	12.0	15.0	18.0	16.0	12.0	11.0
Sulfate (ppm)	1972	13.0	10.0	10.0	33.0	17.0	22.0	23.0
Cond. $\frac{(\text{Micromhos})}{\text{cm}}$	1972	172.0	140.0	104.0	260.0	198.0	270.0	50.0

(Continued)

(CONTINUED)

PARAMETER		HOLDEN	LANCASTER	STERLING	TOWNSEND	LINCOLN	NEEDHAM	WESTON
pH	1971	6.4	6.8	6.5	6.4	6.3	6.6	6.6
	1972	6.1	6.8	6.2	6.2	6.8	6.8	6.2
Alkalinity (ppm)	1971	11.0	24.0	27.0	12.0	24.0	38.0	45.0
	1972	15.0	27.0	23.0	10.0	5.0	55.0	47.0
Hardness (ppm)	1971	27.0	33.0	75.0	15.0	74.0	73.0	158.0
	1972	26.0	32.0	64.0	10.0	12.0	74.0	210.0
Iron (ppm)	1971	0.00	0.0	0.01	0.01	0.54	0.00	0.06
	1972	0.07	0.01	0.04	0.01	0.13	0.01	0.19
Manganese (ppm)	1971	0.00	0.00	0.00	0.00	0.02	0.00	0.02
	1972	0.30	0.00	0.02	0.00	0.13	0.01	0.04
Ammonia N (ppm)	1971	<0.01	0.00	0.00	0.00	0.06	0.01	0.00
	1972	0.08	0.00	0.00	0.00	0.00	0.00	0.01
Nitrate N (ppm)	1971	0.05	0.7	0.8	0.4	0.4	2.0	0.8
	1972	0.04	0.7	0.5	0.5	0.0	0.6	1.0
Chlorides (ppm)	1971	19.0	6.0	34.0	8.0	37.0	54.0	173.0
	1972	20.0	5.0	39.0	8.0	6.0	34.0	254.0
Sodium (ppm)	1971	16.0	5.0	23.0	5.0	11.0	21.0	55.0
	1972	10.0	5.0	24.0	5.0	5.0	17.0	102.0
Potassium (ppm)	1971						1.7	1.0
	1972	1.3	0.5	3.5	0.8	0.7	1.4	3.2
Silica (ppm)	1971						12.0	6.0
	1972	12.0	15.0	11.0	12.0	0.6	17.0	17.0
Sulfate (ppm)	1971						25.0	12.0
	1972	14.0	6.0	40.0	2.0	11.0	10.0	26.0
Cond. (Micromhos/cm)	1971						300.0	100.0
	1972	120.0	85.0	242.0	54.0	52.0	222.0	819.0

CAPE COD

PARAMETER		YARMOUTH	PROVINCETOWN	ORLEANS	EASTHAM	DENNIS
pH	1971	6.1	6.6	6.4	6.6	6.0
	1972	6.1	6.4	6.1	6.8	5.8
Alkalinity (ppm)	1971	8.0	12.0	10.0	15.0	9.0
	1972	10.0	10.0	9.0	95.0	6.0
Hardness (ppm)	1971	11.0	30.0	16.0	36.0	13.0
	1972	16.0	43.0	14.0	13.0	10.0
Iron (ppm)	1971	0.03	0.27	0.04	0.17	0.11
	1972	0.04	0.13	0.02	0.03	0.22
Manganese (ppm)	1971	<0.01	0.08	<0.01	0.32	<0.01
	1972	0.02	0.17	0.02	0.00	0.02
Ammonia N (ppm)	1971	0.00	0.00	0.00	0.00	0.01
	1972	<0.01	0.01	0.00	0.00	<0.01
Nitrate N (ppm)	1971	0.2	0.4	0.0	7.2	0.4
	1972	0.4	0.4	0.0	4.1	0.3
Chlorides (ppm)	1971	23.0	69.0	17.0	41.0	18.0
	1972	28.0	90.0	19.0	42.0	18.0
Sodium (ppm)	1971	15.0	30.0	12.0	23.0	11.0
	1972	18.0	52.0	12.0	87.0	11.0
Potassium (ppm)	1972	0.9	1.9	0.8	1.3	0.7
Silica (ppm)	1972	12.0	13.0	11.0	17.0	7.0
Sulfate (ppm)	1972	1.0	6.0	4.0	23.0	5.0
Cond. ($\frac{\text{Micromhos}}{\text{cm}}$)	1972	114.0	310.0	80.0	370.0	78.0

APPENDIX E

BOTANICAL CHARACTERISTICS OF TWENTY TERRESTRIAL SITES IN NORTHEASTERN MASSACHUSETTS AND CAPE COD

SITE #1

Site Number 1 is primarily a mixed (hardwood and softwood) woodland area, with a small amount of field and pasture land at the norther perimeter of the site.

PRINCIPAL OVERSTORY SPECIES

Pinus strobus
Eastern White Pine

Quercus rubra
Red Oak

ASSOCIATED OVERSTORY SPECIES

Acer rubrum
Red Maple

Acer saccharum
Sugar Maple

Betula lenta
Black Birch

Betula papyrifera
White Birch

Betula populifolia
Gray Birch

Carya ovalis
Sweet Pignut Hickory

Quercus alba
White Oak

Quercus velutina
Black Oak

PRINCIPAL UNDERSTORY SPECIES

Acer rubrum
Red Maple

Betula lenta
Black Birch

Betula papyrifera
White Birch

Pinus strobus
Eastern White Pine

Vaccinium corymbosum
Highbush Blueberry

Viburnum recognitum
Arrow-wood

SITE #1 (cont.)

ASSOCIATED UNDERSTORY SPECIES

Betula populifolia
Gray Birch

Carya sp.
Hickory

Castanea dentata
Chestnut

Cornus stolonifera
Red-Osier Dogwood

Fraxinus americana
White Ash

Juniperus communis
Ground Juniper

Kalmia angustifolia
Sheep Laurel

Ostrya virginiana
Hornbeam

Pinus strobus
Eastern White Pine

Prunus serotina
Black Cherry

Quercus alba
White Oak

Quercus bicolor
Swamp White Oak

Quercus rubra
Red Oak

Ulmus rubra
Slippery Elm

Viburnum acerifolium
Mapleleaf Viburnum

Viburnum cassinoides
Witherod, Wild-Raisin

Vitis sp.
Grape (vine)

PRINCIPAL GROUND COVER SPECIES

Aster cordifolius
Aster

Chimaphila maculata
Pipsissewa

Coptis groenlandica
Goldthread

Cynanthus nigrum
Climbing Milkweed

Cypripedium sp.
Lady's Slipper

Danthonia spicata
Poverty Grass

Dryopteris spinulosa
Spinulose Wood-fern

Lycopodium clavatum
Running Clubmoss

SITE #1 (cont.)

PRINCIPAL GROUND COVER SPECIES (CONT.)

Lycopodium obscurum
Ground Pine

Maianthemum canadense
Canada Mayflower

Medeola virginiana
Indian Cucumber

Onoclea sensibilis
Sensitive Fern

Osmunda regalis
Royal Fern

Pyrola rotundifolia
Wild Lily-of-the-Valley

Rhus radicans
Poison Ivy

Rubus pubescens
Trailing *Rubus*

Smilacina racemosa
False Solomon's Seal

Viola sp.
Violet

SITE #2

Site Number 2 is primarily forested, with a few fields (pastures and meadows) at the eastern and northern perimeters of the area. This area has been logged in the recent past. Many White Pine, (*Pinus strobus*), with a d.b.h. of 20-28 inches, are found in the forest.

There is an apple orchard located at the southeastern portion of the site, and a small orchard at the area's southwest corner.

MIXED FOREST

PRINCIPAL OVERSTORY SPECIES

Acer rubrum
Red Maple

Betula papyrifera
White Birch

Fagus grandifolia
Beech

Pinus strobus
Eastern White Pine

Quercus rubra
Red Oak

Tsuga canadensis
Hemlock

ASSOCIATED OVERSTORY SPECIES

Acer saccharum
Sugar Maple

Betula populifolia
Gray Birch

Fraxinus americana
White Ash

Pinus resinosa
Red Pine

Populus grandidentata
Big-toothed Aspen

Populus tremuloides
Quaking Aspen

Prunus serotina
Black Cherry

Robinia Pseudo - Acacia
Black Locust

SITE #2 (cont.)

PRINCIPAL UNDERSTORY SPECIES

Acer rubrum
Red Maple

Castanea dentata
Chestnut

Hamamelis virginiana
Witch-Hazel

Kalmia angustifolia
Sheep Laurel

Pinus strobus
Eastern White Pine

Prunus serotina
Black Cherry

Vaccinium angustifolium
Lowbush Blueberry

ASSOCIATED UNDERSTORY SPECIES

Acer rubrum
Red Maple

Acer saccharum
Sugar Maple

Betula lenta
Black Birch

Betula papyrifera
White Birch

Betula populifolia
Gray Birch

Fagus grandifolia
Beech

Juniperus communis
Ground Juniper

Kalmia latifolia
Mountain Laurel

Pinus resinosa
Red Pine

Quercus alba
White Oak

Quercus bicolor
Swamp White-Oak

Quercus rubra
Red Oak

Quercus velutina
Black Oak

Rhus typhina
Staghorn Sumac

Sassafras albidum
White Sassafras

Tsuga canadensis
Eastern Hemlock

Ulmus rubra
Slippery Elm

Vaccinium corymbosum
Highbush Blueberry

Viburnum recognitum
Arrow-wood

SITE #2 (cont.)

PRINCIPAL GROUND COVER SPECIES

Dennstaedtia punctilobula
Hay-scented fern

Lycopodium clavatum
Common Club-moss

Lycopodium complanatum
Trailing Evergreen, Ground Pine

Lycopodium obscurum
Ground Pine

Rubus pubescens
Trailing Rubus

ASSOCIATED GROUND COVER SPECIES

Aralia nudicaulis
Wild Sarsaparilla

Carex debilis
Sedge

Cypripedium sp.
Lady's Slipper

Gaultheria procumbens
Teaberry, Checkerberry

Maianthemum canadense
Canada Mayflower

Medeola virginiana
Indian Cucumber

Mitchella repens
Partridge Berry

Onoclea sensibilis
Sensitive Fern

Osmunda cinnamomea
Cinnamon Fern

Osmunda regalis
Royal Fern

Polygonatum pubescens
True Solomon's Seal

Polytrichum commune
Hairy Cap Moss

Pteridium aquilinum
Bracken Fern

Solidago rugosa
Goldenrod

OLD FIELD (MEADOW)

Scattered throughout the field were the following tree species:

Acer platanoides
Norway Maple

Larix laricina
Tamarack

SITE #2 (cont.)

OLD FIELD (MEADOW) (CONT.)

Prunus serotina
Black Cherry

PRINCIPAL GROUND COVER SPECIES

Agrostis alba
Redtop Grass

Agrostis tenuis
Rhode Island Bent Grass

Asclepias syriaca
Common Milkweed

Aster acuminatus
Aster

Aster divaricatus
Aster

Dactylis glomerata
Orchard Grass

Linaria vulgaria
Butter-and-Eggs

Plantago major
Plantain

Rubus pubescens
Trailing *Rubus*

Rumex crispus
Yellow Dock

Setaria glauca
Foxtail grass,
Pigeon grass

APPLE ORCHARD - DOMINANT TREE

Pyrus malus
Apple

APPLE ORCHARD - FREQUENT

GROUND COVER SPECIES

Agrostis alba
Redtop Grass

Agrostis tenuis
Rhode Island Bent Grass

Ambrosia artimisiifolia
Common Ragweed

Daucus carota
Wild Carrot,
Queen Anne's Lace

SITE #2 (cont.)

GROUND COVER SPECIES (CONT.)

Phleum pratense
Timothy

Plantago major
Plantain

Setaria glauca
Foxtail grass, Pigeon Grass

Taraxacum officinale
Common Dandelion

Trifolium pratense
Red Field Clover

SITE #3

Site Number 3 consists of forested highlands with the exception of an apple orchard at the southeast position. There are fields located along the northwest and an old orchard at the northeast boundary.

PRINCIPAL OVERSTORY SPECIES

Betula lenta
Black Birch

Pinus strobus
Eastern White Pine

Quercus alba
White Oak

Quercus rubra
Red Oak

Quercus velutina
Black Oak

ASSOCIATED OVERSTORY SPECIES

Acer rubrum
Red Maple

Acer saccharum
Sugar maple

Betula populifolia
Gray Birch

Betula papyrifera
White Birch

Carya ovalis
Sweet Pignut Hickory

Fagus grandifolia
Beech

Fraxinus americana
White Ash

Nyssa sylvatica
Sourgum, Black Gum

Pinus rigida
Pitch Pine

Prunus serotina
Black Cherry

Quercus coccinea
Scarlet Oak

Tilia americana
Basswood

Ulmus rubra
Slippery Elm

SITE #3 (cont.)

PRINCIPAL UNDERSTORY SPECIES

Acer rubrum
Red Maple

Betula lenta
Black Birch

Juniperus communis
Ground Juniper

Pinus strobus
Eastern White Pine

Prunus serotina
Black Cherry

Quercus alba
White Oak

Quercus rubra
Red Oak

Sassafras albidum
Sassafras

Vaccinium angustifolium
Lowbush Blueberry

Viburnum acerifolium
Mapleleaf Viburnum

ASSOCIATED UNDERSTORY SPECIES

Acer saccharum
Sugar Maple

Carya ovalis
Sweet Pignut Hickory

Castanea dentata
Chestnut

Comptonia peregrina
Sweet Fern

Juniperus virginiana
Red Cedar

Nyssa sylvatica
Sourgum, Black Gum

Populus grandidentata
Bigtooth Aspen

Populus tremuloides
Quaking Aspen

Pyrola rotundifolia
Wild Lily-of-the-Valley

Quercus prinus
Chestnut Oak

Tsuga canadensis
Eastern Hemlock

Vaccinium corymbosum
Highbush Blueberry

Vaccinium vacillans
Sugar Huckleberry

Viburnum cassinoides
Witherod, Wild Raisin

Viburnum recognitum
Arrow-wood

SITE #3 (cont.)

PRINCIPAL GROUND COVER SPECIES

Chimaphila umbellata
Pipsissewa

Gaultheria procumbens
Teaberry, Checkerberry

Pteridium aquilinum
Bracken Fern

ASSOCIATED GROUND COVER SPECIES

Corex pensylvanica
Sedge

Chimaphila maculata
Pipsissewa

Danthonia spicata
Poverty Grass

Dennstaedtia punctilobula
Hayscented Fern

Goodyera tesselata
Rattlesnake Plantain

Lycopodium obscurum
Ground Pine

Lycopodium complanatum
Ground Pine, Trailing Evergreen

Mitchella repens
Partridge Berry

Monotropa uniflora
Indian Pipe

Osmunda cinnamomea
Cinnamon Fern

Polygonatum pubescens
True Solomon's Seal

Rubus pubescens
Trailing Rubus

Solidago caesia
Goldenrod

APPLE ORCHARD

PRINCIPAL OVERSTORY SPECIES

Pyrus malus
Apple

SITE #3 (cont.)

TREES AND SHRUBS IN ORCHARD

Berberis vulgaris
Barberry

Hypericum perforatum
St. John's Wort

Juniperus communis
Ground Juniper

Juniperus virginiana
Red Cedar

Populus grandidentata
Bigtoothed Aspen

Prunus serotina
Black Cherry

Rosa sp.
Rose

Rubus idaeus
Red Raspberry

PRINCIPAL GROUND COVER SPECIES

Agrostis alba
Redtop grass

Andropogon scoparius
Broom Beargrass

Asclepias syriaca
Common Milkweed

Daucus carota
Wild Carrot, Queen Anne's Lace

Phleum pratense
Timothy

Rubus pubescens
Trailing Rubus

Setaria glauca
Foxtail Grass,
Pigeon Grass

ASSOCIATED GROUND COVER SPECIES

Aster acuminatus
Aster

Aster virginiensis
Aster

Aster novae-anglii
New England Aster

Plantago major
Plantain

Rhus radicans
Poison Ivy

Rudbeckia serotina
Black-Eyed Susan

Spiraea latifolia
Meadowsweet

SITE #4

Site Number 4 is primarily a forested site lying to the west of Walden Pond. The forest is relatively open underneath (park-like) with a thick duff layer on the floor.

PRINCIPAL OVERSTORY SPECIES

Pinus strobus
Eastern White Pine

Quercus alba
White Oak

Quercus coccinea
Scarlet Oak

Quercus rubra
Red Oak

Quercus velutina
Black Oak

ASSOCIATED OVERSTORY SPECIES

Acer rubrum
Red Maple

Fraxinus americana
White Ash

Tsuga canadensis
Eastern Hemlock

PRINCIPAL UNDERSTORY SPECIES

Acer rubrum
Red Maple

Carya cordiformis
Bitternut Hickory

Castanea dentata
Chestnut

Quercus alba
White Oak

Quercus coccinea
Scarlet Oak

Quercus rubra
Red Oak

Quercus velutina
Black Oak

SITE #4 (cont.)

ASSOCIATED UNDERSTORY SPECIES

Acer pensylvanicum
Striped Maple

Betula papyrifera
White Birch

Kalmia angustifolia
Sheep Laurel

Populus grandidentata
Bigtooth Aspen

Prunus serotina
Black Cherry

Quercus coccinea
Scarlet Oak

Sassafras albidum
Sassafras

Tsuga canadensis
Eastern Hemlock

Vaccinium angustifolium
Lowbush Blueberry

Vaccinium corymbosum
Highbush Blueberry

Vaccinium vascillans
Sugar Huckleberry

Viburnum acerifolium
Mapleleaf Viburnum

Viburnum recognitum
Arrow-wood

PRINCIPAL GROUND COVER SPECIES

Carex debilis
Sedge

Gaultheria procumbens
Teaberry, Checkerberry

Lycopodium complanatum
Ground Pine, Trailing Evergreen

Lycopodium obscurum
Ground Pine

Maianthemum canadense
Canada Mayflower

Pteridium aquilinum
Bracken Fern

ASSOCIATED GROUND COVER SPECIES

Aralia nudicaulis
Wild Sarsaparilla

Aster acuminatus
Aster

Chimaphila umbellata
Pipsissewa

Cypripedium sp.
Lady's Slipper

SITE #4 (cont.)

ASSOCIATED GROUND COVER SPECIES (CONT.)

Dennstaedtia punctilobula
Hayscented Fern

Mediola virginiana
Indian Cucumber

Onoclea sensibilis
Sensitive Fern

Osmunda cinnamomea
Cinnamon Fern

Smilacena racemosa
False Solomon's Seal

Solidago rugosa
Goldenrod

CLEARINGS

There are small clearings in the area which are inhabited by:

Betula populifolia
Gray Birch

Comptonia peregrina
Sweet Fern

Juniperus virginiana
Red Cedar

Populus tremuloides
Quaking Aspen

SITE #5

Site 5 is mostly forested with some fields located along the western and southern perimeter. Two fields are located in the north. A small apple orchard is located to the south of Ballis Hill Road and a marsh area north of Still Pond in the northeastern portion.

The forest is mixed with some large white pine 36 - 40 inches DBH; most are between 18 - 22 inches DBH.

MIXED FOREST

PRINCIPAL OVERSTORY SPECIES

Pinus strobus
Eastern White Pine

Quercus rubra
Red Oak

Quercus alba
White Oak

Quercus velutina
Black Oak

ASSOCIATED OVERSTORY SPECIES

Acer rubrum
Red maple

Quercus alba
White Oak

Betula papyrifera
White Birch

Quercus coccinea
Scarlet Oak

Betula populifolia
Gray Birch

Tsuga canadensis
Eastern Hemlock

PRINCIPAL UNDERSTORY SPECIES

Pinus strobus
Eastern White Pine

Quercus alba
White Oak

Vaccinium angustifolium
Lowbush Blueberry

Vaccinium corymbosum
Highbush Blueberry

ASSOCIATED UNDERSTORY SPECIES

Acer rubrum
Red Maple

Betula lenta
Black Birch

Betula papyrifera
White Birch

Carya cordiformis
Bitternut Hickory

Carya ovata
Shagbark Hickory

Castanea dentata
Chestnut

Juniperus communis
Dwarf Juniper

Kalmia angustiflora
Sheep Laurel

Kalmia latifolia
Mountain laurel

Prunus serotina
Black Cherry

Quercus bicolor
Swamp White Oak

Rhamnus frangula
Alder Buckthorn

Sassafras albidum
Sassafras

Tsuga canadensis
Eastern Hemlock

Ulmus rubra
Slippery Elm

Viburnum sp.
Viburnum

PRINCIPAL GROUND COVER

Aralia nudicaulis
Wild Sarsaparilla

Lycopodium complanatum
Ground Pine, Trailing Evergreen

Lycopodium obscurum
Ground Pine

Mitchella repens
Partridge Berry

Pteridium aquilinum
Bracken Fern

ASSOCIATED GROUND COVER

Carex debilis
Sedge

Chimaphila maculata
Pipsessewa

Cornus canadensis
Bunchberry

Cypripedium sp.
Lady's Slipper

Dennstaedtia punctilobula
Hayscented Fern

Maianthemum canadense
Canada Mayflower

Monotropa uniflora
Indian Pipe

Osmunda cinnamomea
Cinnamon Fern

Osmunda regalis
Royal Fern

Polytrichium commune
Hairy Cap Moss

Pyrola rotundifolia
Wild Lily-of-the-Valley

Rhus radicans
Poison Ivy

Rubus pubescens
Trailing Rubus

Smilacena racemosa
False Solomon's Seal

Smilax rotundifolia
Smilax

Trientalis borealis
Starflower

Viburnum recognitum
Arrow-wood

FIELD AND PASTURE AREA

The following trees are found scattered throughout the field:

Acer rubrum
Red Maple

Betula papyrifera
White Birch

Betula populifolia
Gray Birch

Juniperus communis
Ground Juniper

Juniperus virginiana
Red Cedar

Larix laricina
Tamarack

Pinus strobus
Eastern White Pine

Pyrus malus
Apple

Quercus alba
White Oak

Quercus coccinea
Red Oak

Quercus rubra
Scarlet Oak

Tsuga canadensis
Eastern Hemlock

PRINCIPAL GROUND COVER SPECIES

Andropogon scoparius
Broom-Bear Grass

Danthonia spicata
Poverty Grass

Eragrostis spectabilis
Tumble Grass

Polytrichium commune
Hairy Cap Moss

Setaria glauca
Foxtail Grass, Pigeon Grass

Trifolium pratense
Red Field Clover

ASSOCIATED GROUND COVER SPECIES

Achillea millefolium
Yarrow

Antennaria neglecta
Cudweed

Asclepias syriaca
Milkweed

Aster novae-anglii
New England Aster

Daucus carota
Wild Carrot, Queen Anne's Lace

Leontodon autumnalis
Fall Dandelion

Oxalis corniculata
Wood Sorrel

Plantago major
Plantain

Potentilla canadensis
Cinquefoil

Rumex crispus
Yellow Dock

SITE #6

The western portion of site 6 has steeper hills and is forested, whereas the eastern portion has more gentle relief and is primarily in pasture and old fields with a small amount of agricultural land. The fields are bounded by wooded fence rows.

MIXED FOREST

PRINCIPAL OVERSTORY SPECIES

Betula papyrifera
White Birch

Betula populifolia
Gray Birch

Quercus coccinea
Scarlet Oak

Quercus rubra
Red Oak

ASSOCIATED OVERSTORY SPECIES

Acer rubrum
Red Maple

Carya ovalis
Sweet Pignut Hickory

Pinus strobus
Eastern White Pine

Quercus alba
White Oak

Quercus bicolor
Swamp White Oak

PRINCIPAL UNDERSTORY SPECIES

Acer rubrum
Red Maple

Carya ovalis
Sweet Pignut Hickory

Kalmia angustifolia
Sheep Laurel

Pinus strobus
Eastern White Pine

Quercus alba
White Oak

Quercus bicolor
Swamp White Oak

Vaccinium corymbosum
Highbush Blueberry

ASSOCIATED UNDERSTORY SPECIES

Juniperus communis
Ground Juniper

Pyrus arbutifolia
Red Chokeberry

Pyrus malus
Apple

Salix alba
White Willow

Vaccinum angustifolium
Lowbush Blueberry

Viburnum acerifolium
Mapleleaf Viburnum

Viburnum recognitum
Arrow wood

PRINCIPAL GROUND COVER SPECIES

Lycopodium complanatum
Ground Pine, Trailing Evergreen

Lycopodium obscurum
Ground Pine

ASSOCIATED GROUND COVER SPECIES

Aralia nudicaulis
Wild Sarsaparilla

Chimaphila maculata
Pipsessewa

Cypripedium sp.
Lady's Slipper

Dennstaedtia punctilobula
Hayscented Fern

Gaultheria procumbens
Teaberry, Checkerberry

Lycopodium clavatum
Common Club Moss

Maianthemum canadense
Canada Mayflower

Mitchella repens
Partridge Berry

Osmunda cinnamomea
Cinnamon Fern

Osmunda claytonia
Interrupted Fern

Osmunda regalis
Regal Fern

Pteridium aquilinum
Bracken Fern

Rubus pubescens
Trailing Rubus

Trientalis borealis
Starflower

OLD FIELD AND PASTURE

PRINCIPAL GROUND COVER SPECIES

Amaranthus retroflexus
Pigweed

Ambrosia artemisiifolia
Ragweed

Daucus carota
Wild Carrot, Queen Anne's Lace

Hordeum sp.
Barley

Plantago major
Plantain

Polygonum aviculare
Knotweed

Polygonum Persecaria
Lady's Thumb

Rubus sp.
Raspberry

Spiraea tomentosa
Meadow sweet

Trifolium pratense
Red Field Clover

ASSOCIATED GROUND COVER SPECIES

Agrostis alba
Redtop Grass

Aster acuminatus
Aster

Aster ericoides
Aster

Aster novae-angli
New England Aster

Asclepias syriaca
Common milkweed

Carex communus
Sedge

Chenopodium album
Pigweed

Chrysanthemum lencanthum
Daisy

Cyperus esculentis
Sedge

Danthonia spicata
Poverty Grass

Eleocharis obtusa
Spikerush

Elymus canadensis
Wild Rye

Galium sp.
Smooth Bedstraw

Glechoma sp.
Creeping Jenny

Juncus sp.
Rush

Linaria vulgaris
Butter 'n' eggs

Lythrum salicaria
Loosestrife

Mentha sp.
Mint

Onoclea sensibilis
Sensitive Fern

Oxalis corniculata
Wood sorrel

Phleum pratense
Timothy

Plantago lanceolata
Plantain

Prunella vulgaris
Selfheal

Rumex crispus
Yellow Dock

Scirpus atrovirens
Bullrush

Setaria glauca
Foxtail Grass, Pigeon Grass

Solidago graminifolia
Goldenrod

Solidago rugosa
Goldenrod

Spillaria graminea
Stitchwort

Spiraea latifolia
Meadowsweet

Taraxacum officenale
Common dandelion

Trifolium pratense
Red Field Clover

Vicia cracca
Hairy Vetch

FENCE ROWS BORDERING FIELDS

Vegetation along fence rows consists of:

Acer negundo
Box elder

Acer plantanoides
Norway Maple

Acer rubrum
Red Maple

Alnus rugosa
Speckeled Alder

Betula populifolia
Gray Birch

Carya ovalis
Sweet Pignut Hickory

Cornus florida
Flowering Dogwood

Juniperus communis
Ground Juniper

Osmunda cinnamomea
Cinnamon Fern

Onoclea sensibilis
Sensitive Fern

Parthenocissus quinquefolia
Virginia creeper

Populus tremuloides
Quaking aspen

Prunus serotina
Black Cherry

Pyrus communis
Pear

Pyrus malus
Apple

Pyrus melanocarpa
Black Chokeberry

Quercus alba
White Oak

Quercus coccinea
Scarlet Oak

Quercus rubra
Red Oak

Rhus radicans
Poison Ivy

Rhus typhina
Staghorn Sumac

Rubus sp.
Raspberry

Salix sp.
Willow

Sassafras albidum
Sassafras

Solidago rugosa
Goldenrod

Spiraea latifolia
Meadowsweet

Ulmus americana
American Elm

Vaccinium corymbosum
Highbush blueberry

Viburnum recognitum
Arrow wood

Vitis sp.
Grape

SITE #7

This site is composed of pasture land and an orchard in the north (Kimball Hill). The central portions and the hill in the south are forested with mixed stands. The extreme southern tip is composed of pasture and agricultural lands (vegetable crops).

MIXED FOREST

PRINCIPAL OVERSTORY SPECIES

Quercus rubra
Red Oak

ASSOCIATED OVERSTORY SPECIES

Acer rubrum
Red Maple

Acer saccharum
Sugar Maple

Betula papyrifera
White Birch

Betula populifolia
Gray Birch

Carya ovata
Shagbark Hickory

Fagus grandifolia
Beech

Pinus rigida
Pitch Pine

Pinus strobus
Eastern White Pine

Robina - Pseudo - Acacia
Black Locust

Quercus alba
White Oak

Quercus rubra
Red Oak

Quercus velutina
Black Oak

Ulmus Americana
American Elm

PRINCIPAL UNDERSTORY SPECIES

Acer rubrum
Red Maple

Carya ovalis
Shagbark Hickory

Pinus strobus
Eastern White Pine

Prunus serotina
Black Cherry

Rubus sp.
Raspberry

Vaccinium angustifolium
Lowbush Blueberry

Vaccinium corymbosum
Highbush Blueberry

Viburnum acerifolium
Mapleleaf Viburnum

ASSOCIATED UNDERSTORY SPECIES

Betula papyrifera
White Birch

Castanea dentata
Chestnut

Cornus florida
Flowering Dogwood

Quercus alba
White Oak

Rubus setosus
Bristly Blackberry

Smilax rotundiflora
Smilax

Viburnum cassinoides
Witherod, Wild Raisin

Viburnum recognitum
Arrow wood

PRINCIPAL GROUND COVER SPECIES

Aralia nudicaulis
Wild Sarsaparilla

Lycopodium obscurum
Ground Pine

ASSOCIATED GROUND COVER SPECIES

Aster acuminatus
Aster

Carex communis
Sedge

Carex debilis
Sedge

Celastrus scandens
Bittersweet

Chimaphila maculata
Pipsessewa

Chimaphila umbellata
Pipsessewa

Danthonia spicata
Poverty Grass

Galium sylvaticum
Baby's Breath

Gaultheria procumbens
Teaberry, Checkerberry

Lycopodium complanatum
Trailing Evergreen, Ground Pine

Medeola virginiana
Indian Cucumber

Maianthemum canadense
Canada Mayflower

Mitchella repens
Partridge Berry

Monotropa Hypopithys
Pinesap

Monotropa uniflora
Indian Pipe

Polygonatum pubescens
True Solomon's Seal

Polytrichum commune
Hairy Cap Moss

Potentilla sp.
Cinquefoil

Pyrola elliptica
Shinleaf

Pyrola rotundifolia
Wild Lily-of-the-Valley

Rubus pubescens
Trailing Rubus

Smilacena racemosa
False Solomon's Seal

Solidago caesia
Goldenrod

GRAZED AND UNGRAZED PASTURES

GROUND COVER

Achilea Millefolium
Yarrow

Agrostis alba
Redtop Grass

Ambrosia artemisiifolia
Common Ragweed

Asclepias syriaca
Common Milkweed

Aster ericoides
Aster

Aster novea-anglii
New England Aster

Berberis vulgaris
Barberry

Celastrus scandens
Bittersweet

Dactylis glomerata
Orchard Grass

Daucus carota
Wild Carrot, Queen Anne's Lace

Dryopteris spinulosa
Spinulose - Wood Fern

Galium sp.
Smooth Bedstraw

Gnaphalum obtusifolium
Cudweed, Everlasting

Hypericum sp.
St. John's - Wort

Juniperus communis
Ground Juniper

Leontodon sp.
Wild - Dandelion

Linaria vulgaris
Butter and Eggs

Lythrum salicaria
Loosestrife

Mentha sp.
Mint

Oxalis corniculata
Wood Sorrel

Parthenocissus inserta
Virginia creeper

Phalaris arundinacea
Reed Canary Grass

Plantago lanceolata
Plantain

Polygonum sp.
Smartweed

Polytrichum commune
Hairy Cap Moss

Potentilla sp.
Cinquefoil

Rhus Radicans
Poison Ivy

Rosa virginia
Rose

Rubus pubescens
Trailing Rubus

Solanum carolinease
Horse-nettle

Solanum dulcamara
Nightshade

Solidago bicolor
Silverrod

Solidago graminifolia
Goldenrod

Solidago rugosa
Goldenrod

Spiraea latifolia
Meadowsweet

Trifolium repens
White Clover

Trifolium pratense
Red Field Clover

Vicia cracca
Hairy Vetch

Verbascum sp.
Mullein

VEGETATION ALONG FENCE ROWS

SURROUNDING PASTURES

Betula populifolia
Gray Birch

Carya ovata
Shagbark Hickory

Juniperus virginiana
Red Cedar

Pinus strobus
Eastern White Pine

Prunus serotina
Black Cherry

Pyrus communis
Pear

Pyrus malus
Apple

Ulmus americana
American Elm

Viburnum recognitum
Arrow-wood

Vitis sp.
Grape

SITE #8

Site 8 is almost entirely forested.

MIXED FOREST

PRINCIPAL OVERSTORY SPECIES

Pinus strobus
Eastern White Pine

Quercus alba
White Oak

Quercus coccinae
Scarlet Oak

Quercus rubra
Red Oak

Quercus velutina
Black Oak

ASSOCIATED OVERSTORY SPECIES

Acer rubrum
Red Maple

Betula papyrifera
White Birch

Betula populifolia
Gray Birch

Pinus rigida
Pitch Pine

Populus grandidentata
Bigtoothed Aspen

Prunus serotina
Black Cherry

PRINCIPAL UNDERSTORY SPECIES

Betula papyrifera
White Birch

Castanea dentata
Chestnut

Kalmia angustifolia
Sheep Laurel

Kalmia latifolia
Mountain Laurel

Prunus serotina
Black Cherry

Quercus rubra
Red Oak

SITE #9

Site 9 is predominately forested (mixed forest) with a very small amount of pasture in the extreme northern portion.

MIXED FOREST

PRINCIPAL OVERSTORY SPECIES

Acer rubrum
Red Maple

Betula papyrifera
White Birch

Betula lenta
Black Birch

Picea rubens
Red Spruce

Pinus strobus
Eastern White Pine

Quercus rubra
Red Oak

ASSOCIATED OVERSTORY SPECIES

Betula alleghaniensis
Yellow Birch

Carya ovata
Shagbark Hickory

Fraxinus americana
White Ash

Picea abies
Norway Spruce

Populus grandidentata
Bigtoothed Aspen

Quercus alba
White Oak

Quercus velutina
Black Oak

Tsuga canadensis
Hemlock

Ulmus americana
American Elm

PRINCIPAL UNDERSTORY SPECIES

Acer rubrum
Red Maple

Betula lenta
Black Birch

Betula papyrifera
White Birch

Ilex verticillata
Winterberry, Black Alder

Juniperus communis
Ground Juniper

Pinus strobus
Eastern White Pine

Prunus serotina
Black Cherry

Quercus rubra
Red Oak

Rubus sp.
Raspberry

Vaccinum angustifolium
Lowbush Blueberry

Vaccinium corymbusom
Highbush Blueberry

Viburnum acerifolium
Mapleleaf Viburnum

ASSOCIATED UNDERSTORY SPECIES

Carya ovata
Shagbark Hickory

Comptonia peregrina
Sweet Fern

Fraxinus americana
White Ash

Juniperus communis
Ground Juniper

Populus grandidentata
Bigtoothed Aspen

Pyrola rotundifolia
Wild Lily-of-the-Valley

Quercus alba
White Oak

Quercus velutina
Black Oak

Tsuga canadensis
Hemlock

Ulmus americana
American Elm

PRINCIPAL GROUND COVER SPECIES

Aralia nudicaulis
Wild Sarsaparilla

Carex crinita
Sedge

Carex folliculata
Sedge

Cypripedium sp.
Lady's Slipper

Dennstaedtia punctilobula
Hayscented Fern

Gaultheria procumbens
Teaberry, Checkerberry

Lycopodium complanatum
Trailing Evergreen, Ground Pine

Lycopodium obscurum
Ground Pine

Miainthemum canadense
Canada Mayflower

Mitchella repens
Partridge Berry

Onoclea sensibilis
Sensitive Fern

Osmunda cinnamomea
Cinnamon Fern

Pteridium aquilinum
Bracken Fern

Rhus radicans
Poison Ivy

ASSOCIATED GROUND COVER SPECIES

Aster acuminatus
Aster

Botrychium dissectum
Grape Fern

Chelone glabra
Turtlehead

Chimaphila umbellata
Pipsissewa

Coptis groenlandica
Goldthread

Goodyera tesselata
Rattlesnake Plantain

Lycopodium clavatum
Common Clubmoss

Monotropa uniflora
Indian Pipe

Osmunda regalis
Royal Fern

Parthenocissus quinquefolia
Virginia Creeper

Polygonatum pubescens
True Solomon's Seal

Polystichum acrosticoides
Christmas Fern

Pyrola rotundifolia
Wild Lily-of-the-Valley

Rubus pubescens
Trailing Rubus

Thaliatrum polyganum
Tall Meadow Rue

SITE #10

This site is primarily forested, with some fields and agricultural areas located along Beaver Brook Road and along Great Road in the south and southeast portion.

MIXED FOREST

PRINCIPAL OVERSTORY SPECIES

Pinus strobus
Eastern White Pine (16-24" in DBH)

ASSOCIATED OVERSTORY SPECIES

Acer rubrum
Red Maple

Betula alleganiensis
Yellow Birch

Fraxinus americana
White Ash

Pseudotsuga Menzeseii
Douglas Fir

Quercus alba
White Oak

Quercus coccinea
Scarlet Oak

Quercus rubra
Red Oak

Tsuga canadensis
Hemlock

PRINCIPAL UNDERSTORY SPECIES

Castanea dentata
Chestnut

Pinus strobus
Eastern White Pine

Quercus alba
White Oak

Quercus rubra
Red Oak

Vaccinium angustifolium
Lowbush Blueberry

Vaccinium corymbosum
Highbush Blueberry

Viburnum acerifolium
Mapleleaf Viburnum

ASSOCIATED UNDERSTORY SPECIES

Acer rubrum
Red Maple

Betula alleganiensis
Yellow Birch

Betula populifolia
Gray Birch

Carya sp.
Hickory

Cornus florida
Flowering Dogwood

Ilex laevigata
Smooth Winterberry

Juniperus communis
Ground Juniper

Kalmia angustifolia
Sheep Laurel

Kalmia latifolia
Mountain Laurel

Picea rubens
Red Spruce

Pinus resinosa
Red Pine

Prunus serotina
Black Cherry

Quercus bicolor
Swamp White Oak

Rhododendron roseum
Pinks Azelea

Tsuga canadensis
Hemlock

Ulmus americana
American Elm

Ulmus rubra
Slippery Elm

PRINCIPAL GROUND COVER SPECIES

Aralia nudicaulis
Wild Sarsaparilla

Cypripedium sp.
Lady Slipper

Gaultheria procumbens
Teaberry, Checkerberry

Lycopodium complanatum
Trailing Evergreen
Ground Pine

Lycopodium obscurum
Ground Pine

Pteridium aquilinum
Bracken Fern

Rubus pubescens
Trailing rubus

ASSOCIATED GROUND COVER SPECIES

Carex debilis
Sedge

Chimaphila umbellata
Pipsessewa

Coptis groenlandica
Goldthread

Danthonia spicata
Poverty Grass

Dryopteri spinulosa
Spinulose - Wood

Maianthemum canadense
Canada Mayflower

Medeola virginiana
Indian Cucumber

Onoclea sensibilis
Sensitive Fern

Osmunda cinnamomea
Cinnamon Fern

Osmunda regalis
Royal Fern

Polytrichum commune
Hairy Cap Moss

Rubus sp.
Raspberry

Smilacena racemosa
False Solomon's Seal

PASTURE - OLD MEADOW

PRINCIPAL GROUND COVER SPECIES

Agrostis alba
Redtop grass

Dactylis glomerata
Orchard Grass

Festuca capillata
Fescue

Phleum pratense
Timothy

ASSOCIATED GROUND COVER SPECIES

Achillea Millefolium
Yarrow

Agropyron repens
Witch Grass

Asclepias syriaca
Common Milkweed

Aster ericoides
Aster

Daucus carota
Wild Carrot, Queen Anne's Lace

Oxalis corniculata
Wood Sorrel

Potentilla canadensis
Cinquefoil

Solanum dulcamara
Nightshade

Solidago gigantea
Goldenrod

Vicia cracca
Hairy Vetch

SITE #11

This site is predominately a scrub forest.

FOREST

PRINCIPAL OVERSTORY SPECIES

Betula populifolia
Gray Birch

Pinus rigida
Pitch Pine

Pinus strobus
Eastern White Pine

Quercus alba
White Oak

ASSOCIATED OVERSTORY SPECIES

Acer rubrum
Red Maple

Populus tremuloides
Quaking Aspen

Prunus serotina
Black Cherry

Quercus coccinae
Scarlet Oak

Quercus velutina
Black Oak

PRINCIPAL UNDERSTORY SPECIES

Comptonia peregrina
Sweet Fern

Quercus ilicifolia
Scrub Oak

Spiraea latifolia
Meadowsweet

Vaccinium angustifolium
Lowbush Blueberry

SITE #11 (Cont.)

ASSOCIATED UNDERSTORY SPECIES

Acer rubrum
Red Maple

Alnus rugosa
Speckeled Alder

Amelanchier canadensis
Shadbush

Betula populifolia
Gray Birch

Castanea dentata
Chestnut

Corylus americana
American Hazelnut

Pinus rigida
Pitch Pine

Populus tremuloides
Quaking Aspen

Prunus serotina
Black Cherry

Quercus alba
White Oak

Salix alba
White Willow

Vaccinium corymbosum
Highbush Blueberry

PRINCIPAL GROUND COVER SPECIES

Agrostis alba
Redtop Grass

Andropogon scoparius
Broom-Bear Grass

Galium sp.
Smooth Bedstraw

Polytrichum commune
Hairycap Moss

Pteridium aquilinum
Bracken Fern

Rubus pubescens
Trailing Rubus

ASSOCIATED GROUND COVER SPECIES

Danthonia spicata
Poverty Grass

Gaultheria procumbens
Teaberry, Checkerberry

Linaria vulgaris
Butter and Eggs

Lycopodium obscurum
Ground Pine

Potentilla simplex
Cinquefoil

SITE #12

Site 12 consists of three habitats designated as the following:

A mixed woodland which occupies most of the area.
Old fields which have not been cultivated or pastured for 1 - 4 years which exist along Ferry Road.
A well "groomed" park - like estate which occupies the southern portion of the area.

MIXED FOREST

PRINCIPAL OVERSTORY SPECIES

Acer rubrum
Red Maple

Fagus grandifolia
Beech

Pinus strobus
Eastern White Pine

Quercus rubra
Red Oak

Quercus velutina
Black Oak

ASSOCIATED OVERSTORY SPECIES

Betula papyrifera
White Birch

Betula populifolia
Gray Birch

Juniperus virginiana
Red Cedar

Pinus rigida
Pitch Pine

Robinia Pseudo - Acacia
Black Locust

Ulmus americana
American Elm

SITE #12 (Cont.)

PRINCIPAL UNDERSTORY SPECIES

Acer rubrum
Red Maple

Berberis vulgaris
Barberry

Betula populifolia
Gray Birch

Juniperus communis
Ground Juniper

Myrica pensylvanica
Bayberry, Candleberry

Parthenocissus quinquefolia
Virginia Creeper

Prunus serotina
Black Cherry

Rhus typhina
Staghorn Sumac

Rubus sp.
Raspberry

Quercus rubra
Red Oak

Quercus velutina
Black Oak

Vaccinium angustifolium
Low-bush Blueberry

Vaccinium corymbosum
Highbush Blueberry

Viburnum acerifolium
Mapleleaf Viburnum

ASSOCIATED UNDERSTORY SPECIES

Comptonia peregrina
Sweet Fern

Glenditsia triacanthos
Honey Locust

Ilex verticellata
Black Alder, Winterberry

Juniperus virginiana
Red Cedar

Prunus serotina
Black Cherry

Rhus glabra
Smooth Sumac

Rosa virginiana
Rose

Smilax herbacea
Carrion-flower

Vaccinium atrocaccum
Black Highbush Blueberry

SITE #12 (Cont.)

PRINCIPAL GROUND COVER SPECIES

Carex pensylvanica
Sedge

Cypripedium sp.
Lady's Slipper

Danthonia spicata
Poverty Grass

Gaultheria procumbens
Teaberry, Checkerberry

Lycopodium complanatum
Trailing Evergreen, Ground Pine

Lycopodium obscurum
Ground Pine

Maianthemum canadense
Canada Mayflower

Mitchella repens
Partridge Berry

Polytrichium commune
Hairycap Moss

Pyrola elliptica
Shinleaf

Rhus radicans
Poison Ivy

ASSOCIATED GROUND COVER SPECIES

Andropogon scoparius
Broom Bear Grass

Aralia nudicaulis
Wild Sarsaparilla

Cornus canadensis
Bunchberry

Dennstaedtia punctilobula
Hayscented Fern

Epifagus virginiana
Beech-drops

Juncus effuses
Soft Rush

Monotropa Hypopithys
Pinesap

Monotropa uniflora
Indian Pipe

Onoclea sensibilis
Sensitive Fern

Prenanthes trifoliata
Gall-of-the-Earth

Pteridium aquilinum
Bracken Fern

Solidago bicolor
Silverrod

Tanacetum vulgare
Common Tansy,
Golden-Buttons

SITE #12 (Cont.)

MEADOW - FIELD

SHRUBS AND TREES

Alnus rugosa
Speckeled Alder

Betula populifolia
Gray Birch

Juniperus virginiana
Red Cedar

Quercus coccinea
Scarlet Oak

Quercus velutina
Black Oak

Robinia Pseudo - Acacia
Black Locust

Spiraea latifolia
Meadowsweet

Ulmus americana
American Elm

Vaccinium corymbosum
Highbush Blueberry

Viburnum recognitum
Arrow-wood

PRINCIPAL GROUND COVER SPECIES

Achillea Millefolium
Yarrow

Agrostis alba
Redtop Grass

Agrostis tenuis
Rhode Island Bent Grass

Amaramthus retroflexus
Pigweed

Aster ericoides
Aster

Aster novae-anglii
New England Aster

Celastrus scandens
Bittersweet

Daucus carota
Wild Carrot, Queen Anne's Lace

Festuca capillata
Fescue

Oxalis corniculata
Wood Sorrel

Panicum capillare
Old Witch-Grass

Potentilla canadensis
Cinquefoil

Setaria glauca
Foxtail Grass

Solidago graminifolia
Goldenrod

Trifolium pratense
Red Field Clover

Vicia cracca
Hairy Vetch

SITE #12 (Cont.)

ASSOCIATED GROUND COVER SPECIES

Aster cordifolius
Aster

Aster linarifolius
Aster

Aster novi-belgii
New York Aster

Chenopodium album
Pigweed

Echinochloa crusgalli
Barnyard Grass

Eupatorium purpureum
Joe Pye-weed

Euphorbia esula
Wolf's Milk, Leafy Spurge

Gerardia purpurea
Gerardia

Impatiens capensis
Touch-me-Not

Lythrum Salicaria
Loosestrife

Medicago sativa
Alfalfa

Onoclea sensibilis
Sensitive Fern

Plantago lanceolata
Plantain

Polygonum aviculare
Knotweed

Polygonum Persicaria
Lady's Thumb

Prunella vulgaris
Self heal

Rudbeckia serotina
Black-eyed-Susan

Solidago nemoralis
Goldenrod

Solidago rugosa
Goldenrod

Viola lanceolata
Lance-leaved violet

PARK-LIKE ESTATE

PRINCIPAL OVERSTORY SPECIES

Acer rubrum
Red Maple

Cornus florida
Flowering Dogwood

Fagus grandifolia
Beech

Picea rubens
Red Spruce

Pinus strobus
Eastern White Pine

Quercus alba
White Oak

SITE #12 (Cont.)

Quercus rubra
Red Oak

Quercus velutina
Black Oak

Tsuga canadensis
Hemlock

ASSOCIATED OVERSTORY SPECIES

Acer saccharum
Sugar Maple

Betula lenta
Black Birch

Betula papyrifera
White Birch

Carya ovata
Shagbark Hickory

Juglans cinerea
Butternut

Picea abies
Norway Spruce

Pseudotsuga Menzesii
Douglas Fir

Pyrus communis
Pear

Pyrus malus
Apple

Ulmus americana
American Elm

UNDERSTORY SPECIES

Kalmia latifolia
Mountain laurel

Rhododendron roseum
Pink Azelias

GROUND COVER SPECIES

Lawn grasses and cultivated herbaceous flowering plants.

SITE #13

This site is predominantly forested with field and pasture areas located in the southern, southeastern and northeastern sections.

MIXED FOREST

PRINCIPAL OVERSTORY SPECIES

Carya ovata
Shagbark Hickory

Fraxinus americana
White Ash

Quercus alba
White Oak

Quercus rubra
Red Oak

Quercus velutina
Black Oak

ASSOCIATED OVERSTORY SPECIES

Acer rubrum
Red Maple

Acer saccharum
Sugar Maple

Betula lenta
Black Birch

Carya cordiformis
Bitternut Hickory

Pinus strobus
Eastern White Pine

Ulmus americana
American Elm

PRINCIPAL UNDERSTORY SPECIES

Betula lenta
Black Birch

Castanea dentata
Chestnut

Pinus strobus
Eastern White Pine

Viburnum acerifolium
Mapleleaf viburnum

SITE #13 (cont.)

ASSOCIATED UNDERSTORY SPECIES

Acer plantanoides
Norway Maple

Acer rubrum
Red Maple

Acer saccharum
Sugar Maple

Carya ovata
Shagbark Hickory

Fraxinus americana
White Ash

Hamamelis virginiana
Witch Hazel

Juniperus communis
Ground Juniper

Kalmia angustifolia
Sheep Laurel

Populus grandidentata
Bigtooth Aspen

Quercus alba
White Oak

Quercus rubra
Red Oak

Quercus velutina
Black Oak

Tsuga canadensis
Hemlock

Vaccinium angustifolium
Lowbush Blueberry

Vaccinium corymbosum
Highbush Blueberry

Viburnum cassinoides
Witherod, Wild Raisin

PRINCIPAL GROUND COVER SPECIES

Gaultheria procumbens
Teaberry, Checkerberry

Mitchella repens
Partridge Berry

SITE #13 (cont.)

ASSOCIATED GROUND COVER SPECIES

Aralia nudicaulis
Wild Sarsaparilla

Aster acuminatus
Aster

Berberis vulgaris
Barberry

Chimophilla umbellata
Pipsessewa

Cypripedium sp.
Lady's Slipper

Dennstaedtia punctilobula
Hayscented Fern

Lycopodium complanatum
Trailing Evergreen, Ground Pine

Lycopodium obscurum
Ground Pine

Maianthemum canadense
Canada Mayflower

Monotropa uniflora
Indian Pipe

Osmunda cinnamomea
Cinnamon Fern

Osmunda regalis
Royal Fern

Polygonatum pubescens
True Solomon's Seal

Pteridium aquilinum
Bracken Fern

Pyrola rotundiflolia
Wild Lily-of-the-Valley

Rhus radicans
Poison Ivy

Smilacena racemosa
True Solomon's Seal

Trientalis borealis
Starflower

FIELD-PASTURE SPECIES

SHRUB SPECIES

Berberis vulgaris
Barberry

Juniperus communis
Ground Juniper

Juniperus virginiana
Red Cedar

Kalmia angustifolia
Sheep Laurel

Rosa virginiana
Rose

SITE #13

PRINCIPAL GROUND COVER SPECIES

Agrostis alba
Redtop Grass

Agrostis tenuis
Rhode Island Bent Grass

Danthonia spicata
Poverty Grass

Phleum pratense
Timothy

Plantago major
Plantain

Trifolium pratense
Red Field Clover

ASSOCIATED GROUND COVER SPECIES

Achillea Millefolium
Yarrow

Asclepias syriaca
Common Milkweed

Andropogon scoparius
Broom Bear Grass

Aster acuminatus
Aster

Aster memoralis
Aster

Aster novae-anglii
New England Aster

Carex communis
Sedge

Cirsium arvense
Canada Thistle

Glechoma sp.
Creeping Jenny

Juncus effusis
Soft Rush

Leodonton sp.
Wild Dandelion

Mentha piperita
Peppermint

Oxalis corniculata
Wood Sorrel

Polygonum sp.
Smartweed

Rhus radicans
Poison Ivy

Rumex crispus
Yellow Dock

Setaria glauca
Foxtail Grass

Solanum dulcamara
Nightshade

Solidago bicolor
Silverrod

Solidago graminifolia
Goldenrod

SITE #13 (cont.)

ASSOCIATED GROUND COVER SPECIES

Taraxum officinale
Common Dandelion

Verbascum sp.
Mullein

Vicia cracca
Hairy Vetch

Vinca minor
Periwinkle

SITE # 14

Site Number 14 is almost entirely forested with the exception of a small amount of meadow area in the extreme northern portion.

MIXED FOREST

PRINCIPAL OVERSTORY SPECIES

Pinus strobus
Eastern White Pine

Quercus rubra
Red Oak

ASSOCIATED OVERSTORY SPECIES

Acer rubrum
Red Maple

Betula populifolia
Gray Birch

Pinus rigida
Pitch Pine

Quercus alba
White Oak

Quercus coccinae
Scarlet Oak

Quercus ilicifolia
Scrub Oak

Quercus prinus
Chestnut Oak

Quercus velutina
Black Oak

PRINCIPAL UNDERSTORY SPECIES

Kalmia angustifolia
Sheep Laurel

Vaccinium angustifolium
Lowbush Blueberry

Vaccinium corymbosum
Highbush Blueberry

SITE #14 (cont.)

ASSOCIATED UNDERSTORY SPECIES

Acer rubrum
Red Maple

Betula populifolia
Gray Birch

Castanea dentata
Chestnut

Pinus strobus
Eastern White Pine

Prunus serotina
Black Cherry

Quercus alba
White Oak

Quercus coccinae
Scarlet Oak

Quercus prinus
Scrub Oak

Quercus rubra
Red Oak

Quercus velutina
Black Oak

Sassafras albidum
White Sassafras

Smilax
Greenbriar

Viburnum cassinoides
Witherod, Wild Raisin

Viburnum recognitum
Arrow-wood

PRINCIPAL GROUND COVER SPECIES

Gaultheria procumbens
Teaberry, Checkerberry

Lycopodium obscurum
Ground Pine

Osmunda cinnamomea
Cinnamon Fern

Pteridium aquilinum
Bracken Fern

Rubus pubescens
Trailing Rubus

SITE #14 (cont.)

ASSOCIATED GROUND COVER SPECIES

Aralia nudicaulis
Wild Sarsaparilla

Carex sp.
Sedge

Chimaphila maculata
Pipsessewa

Coptis groenlandica
Goldthread

Cornus canadensis
Bunchberry

Cypripedium sp.
Lady's Slipper

Maianthemum canadense
Canada Mayflower

Mediola virginiana
Indian Cucumber

Mitchella repens
Partridge Berry

Polytrichum commune
Hairy Cap Moss

MEADOW

TREE AND SHRUB SPECIES

Acer rubrum
Red Maple

Alnus rugosa
Speckled Alder

Betula populifolia
Gray Birch

Comptonia peregrina
Sweet Fern

Cornus amomum
Silky Dogwood

Kalmia angustifolia
Sheep Laurel

Prunus serotina
Black Birch

Salix alba
White Willow

Spiraea latifolia
Meadow Sweet

Spiraea tomentosa
Meadowsweet

Vaccinium angustifolium
Lowbush Blueberry

Viburnum recognitum
Arrow-wood

SITE #14 (cont.)

GROUND COVER SPECIES

Achillea Millefolium
Yarrow

Agrostis alba
Redtop Grass

Andropogon scoparius
Broom Bear Grass

Aster ericoides
Aster

Aster novae-anglii
New England Aster

Carex
Sedge

Danthonia spicata
Poverty Grass

Dennstaedtia punctilobula
Hayscented Fern

Eragrostis spectabilis
Tumble Grass

Gentiana clausa
Closed Gentian

Gnaphalium obtusifolium
Cudweed, Everlasting

Juncus effusus
Soft Rush

Medicago sativa
Alfalfa

Panicum oligosanthes
Panic Grass

Parthenocissus inserta
Virginia Creeper

Phleum pratense
Timothy

Potentilla norvegica
Cinquefoil

Pteridium aquilinum
Hayscented Fern

Rubus pubescens
Trailing Rubus

Solidago bicolor
"White" Goldenrod,
Silver Rod

Solidago graminifolia
Goldenrod

Trifolium pratense
Red Field Clover

Vicia cracca
Hairy Vetch

SITE #15

This site is primarily forested with the exception of a very small pasture area at the northern portion.

MIXED FOREST

PRINCIPAL OVERSTORY SPECIES

Quercus alba
White Oak

Quercus rubra
Red Oak

ASSOCIATED OVERSTORY SPECIES

Acer rubrum
Red Maple

Betula lenta
Black Birch

Betula papyrifera
White Birch

Betula populifolia
Gray Birch

Carya ovalis
Sweet Pignut Hickory

Carya ovata
Shagbark Hickory

Nyssa sylvatica
Sourgum, Black Gum

Pinus resinosa
Red Pine

Pinus strobus
Eastern White Pine

Populus grandidentata
Bigtoothed Aspen

Prunus serotina
Black Cherry

Sassafras albidum
White Sassafras

Tilia americana
Basswood

Tsuga canadensis
Hemlock

SITE #15 (cont.)

PRINCIPAL UNDERSTORY SPECIES

Betula papyrifera
White Birch

Hamamelis virginiana
Witch Hazel

Juniperus communis
Ground Juniper

Kalmia latifolia
Mountain Laurel

Vaccinium angustifolium
Lowbush Blueberry

Vaccinium corymbosum
Highbush Blueberry

ASSOCIATED UNDERSTORY SPECIES

Acer pensylvanicum
Striped Maple

Acer rubrum
Red Maple

Berberis vulgaris
Barberry

Betula lenta
Black Birch

Betula populifolia
Gray Birch

Castanea dentata
Chestnut

Carya ovalis
Sweet Pignut Hickory

Carya ovata
Shagbark Hickory

Cornus amomum
Silky Dogwood

Gaylussacia baccata
Black Huckleberry

Kalmia angustifolia
Sheep Laurel

Picea abiea
Norway Spruce

Ostrya virginiana
Hornbeam

Pinus strobus
Eastern White Pine

Prunus serotina
Black Cherry

Pseudotsuga Menzeseii
Douglas Fir

Pyrus sp.
Chokeberry

Quercus alba
White Oak

Quercus prinus
Scrub Oak

Rhamnus frangula
Alder Buckthorn

SITE #15 (Cont.)

Smilax
Greenbriar

Viburnum acerifolium
Mapleleaf Viburnum

PRINCIPAL GROUND COVER SPECIES

Gaultheria procumbens
Teaberry, Checkerberry

Lycopodium complanatum
Trailing Evergreen, Ground Pine

Lycopodium obscurum
Ground Pine

Mitchella repens
Partridge Berry

Osmunda cinnamomea
Cinnamon Fern

Rubus pubescens
Trailing Rubus

ASSOCIATED GROUND COVER SPECIES

Aster acuminatus
Aster

Carex sp.
Sedge

Coptis groenlandica
Goldthread

Dennstaedia punctilobula
Hayscented Fern

Lycopodium clavatum
Common Club Moss

Maianthemum canadense
Canada Mayflower

Monotropa uniflora
Indian Pipe

Muhlenbergia tenuiflora
Grass

Onoclea sensibilis
Sensitive Fern

Pteridium aquilinum
Bracken Fern

Pyrola rotundifolia
Wild Lily-of-the-Valley

Smilacina racemosa
False Solomon's Seal

SITE #16

Site Number 16 is primarily forested with the exception of a small amount of pasture in the northeastern portion and a small field in the southeast along Rice Road.

MIXED FOREST

PRINCIPAL OVERSTORY SPECIES

Fagus grandifolia
Beech

Pinus strobus
Eastern White Pine

Quercus alba
White Oak

Quercus rubra
Red Oak

Quercus velutina
Black Oak

ASSOCIATED OVERSTORY SPECIES

Acer rubrum
Red Maple

Betula alleganiensis
Yellow Birch

Betula papyrifera
White Birch

Carya cordiformis
Bitternut Hickory

Fraxinus americana
White Ash

Populus tremuloides
Quaking Aspen

Quercus coccinae
Scarlet Oak

Tsuga canadensis
Hemlock

Ulmus rubra
Slippery Elm

SITE #16 (cont.)

PRINCIPAL UNDERSTORY SPECIES

Fagus grandifolia
Beech

Kalmia angustifolia
Sheep Laurel

Pinus strobus
Eastern White Pine

Quercus alba
White Oak

Quercus rubra
Red Oak

Quercus velutina
Black Oak

Vaccinium angustifolium
Lowbush Blueberry

Vaccinium corymbosum
Highbush Blueberry

ASSOCIATED UNDERSTORY SPECIES

Acer rubrum
Red Maple

Acer saccharum
Sugar Maple

Betula alleganiensis
Yellow Birch

Betula lenta
Black Birch

Betula papyrifera
White Birch

Betula populifolia
Gray Birch

Carya cordiformis
Bitternut Hickory

Castanea dentata
Chestnut

Cornus florida
Flowering Dogwood

Fraxinus americana
White Ash

Hamamelis virginiana
Witch Hazel

Juniperus communis
Ground Juniper

Juniperus virginiana
Red Cedar

Ostrya virginiana
Hornbeam

Pinus serotina
Black Cherry

Populus tremuloides
Quaking Aspen

Rhamnus frangula
Alder Buckthorn

Sassafras albidum
White Sassafras

SITE 416 (cont.)

ASSOCIATED UNDERSTORY SPECIES (CONT.)

Tsuga canadensis
Hemlock

Viburnum acerifolium
Mapleleaf Viburnum

PRINCIPAL GROUND COVER SPECIES

Lycopodium complanatum
Trailing Evergreen, Ground Pine

Lycopodium obscurum
Ground Pine

Rubus pubescens
Trailing Rubus

ASSOCIATED GROUND COVER SPECIES

Aralia nudicaulis
Wild Sarsaparilla

Carex debilis
Sedge

Chimaphila maculata
Pipsessewa

Chimaphila umbellata
Pipsessewa

Cypripedium sp.
Lady's Slipper

Dennstaedtia punctilobula
Hayscented Fern

Maianthemum canadense
Canada Mayflower

Medeola virginiana
Indian Cucumber

Mitchella repens
Partridge Berry

Monotropa Hypopithys
Pinesap

Monotropa uniflora
Indian Pipe

Onoclea sensibilis
Sensitive Fern

Osmunda cinnamomea
Cinnamon Fern

Osmunda regalis
Regal Fern

Polygonatum pubescens
True Solomon's Seal

Polytrichum commune
Hairy Cap Moss

Pteridium aquilinum
Bracken Fern

Pyrola rotundiflora
Wild Lily-of-the-Valley

SITE #17

Site Number 17 consists of three habitat areas:

A mixed woodland occupies most of the central and northern portions.
An apple orchard occupies most of the western area and a small portion at the eastern edge.
A small amount of pasture and agricultural (corn) land is in the far west and southwest.

MIXED WOODLAND

PRINCIPAL OVERSTORY SPECIES

Acer rubrum
Red Maple

Acer saccharum
Sugar Maple

Betula lenta
Black Birch

Juniperus virginiana
Red Cedar

Pinus strobus
Eastern White Pine

Quercus rubra
Red Oak

Quercus velutina
Black Oak

ASSOCIATED OVERSTORY SPECIES

Betula populifolia
Gray Birch

Carya ovata
Shagbark Hickory

Fraxinus americana
White Ash

Nyssa sylvatica
Sourgum, Black Gum

Populus tremuloides
Quaking Aspen

Prunus serotina
Black Cherry

Robinia Pseudo-Acacia
Black Locust

Tilia americana
Basswood

SITE #17 (cont.)

ASSOCIATED OVERSTORY SPECIES (CONT.)

Ulmus americana
American Elm

PRINCIPAL UNDERSTORY SPECIES

Acer rubrum
Red Maple

Acer saccharum
Sugar Maple

Carya ovata
Shagbark Hickory

Juniperus virginiana
Red Cedar

Pinus strobus
Eastern White Pine

Rubus sp.
Raspberry

Vaccinium angustifolium
Lowbush Blueberry

ASSOCIATED UNDERSTORY SPECIES

Berberis Thunbergii
Japanese Barberry

Berberis vulgaris
Common Barberry

Fraxinus americana
White Ash

Lonicera villosa
Honeysuckle

Rubus setosus
Bristly Blackberry

Rhus typhina
Staghorn Sumac

Spiraea latifolia
Meadowsweet

Viburnum cassinoides
Witherod, Wild-Raisin

SITE #17 (cont.)

PRINCIPAL GROUND COVER SPECIES

Dennstaedtia punctilobula
Hayscented Fern

Dryopteris spinulosa
Spinulose Wood Fern

Gaultheria procumbens
Teaberry, Checkerberry

Lycopodium complanatum
Trailing Evergreen, Ground Pine

Lycopodium obscurum
Ground Pine

Maianthemum canadense
Canada Mayflower

Mitchella repens
Partridge Berry

Osmunda cinnamomea
Cinnamon Fern

Polytrichum commune
Hairy cap Moss

Rhus radicans
Poison Ivy

Rubus pubescens
Trailing Rubus

ASSOCIATED GROUND COVER SPECIES

Actaea rubra
Red Baneberry

Arisaema atrorubens
Jack-in-the-Pulpit

Coptis groenlandica
Goldthread

Echinochloa crusgalli
Barnyard Grass

Osmunda regalis
Royal Fern

Parthenocissus quinquefolia
Virginia Creeper

Phytolacca americana
Poke Weed

Pyrola rotundifolia
Wild Lily-of-the-Valley

Smilacina racemosa
False Solomon's Seal

SITE #17 (cont.)

APPLE ORCHARD

OVERSTORY SPECIES

Pyrus communis
Pear

Pyrus malus
Apple

UNDERSTORY SPECIES

Rosa virginiana
Rose

Rubus setosus
Bristly Blackberry

PRINCIPAL GROUND COVER SPECIES

Achillea Millefolium
Yarrow

Agrostis alba
Redtop Grass

Dactylis glomerata
Orchard Grass

Phleum pratense
Timothy Grass

Poa pratensis
Kentucky Bluegrass

Polygonum sp.
Smartweed

Rubus pubescens
Trailing Rubus

Setaria glauca
Foxtail Grass

Solidago caesia
Goldenrod

Spireae latifolia
Meadowsweet

ASSOCIATED GROUND COVER SPECIES

Amaranthus retroflexus
Pigweed

Asclepias syriaca
Common Milkweed

Aster acuminatus
Aster

Aster cordifolius
Aster

SITE #17 (cont.)

ASSOCIATED GROUND COVER SPECIES (CONT.)

Carex laxiculmis
Sedge

Chenopodium album
Pigweed

Hieracium prealtum
King David

Linaria vulgaris
Butter and Eggs

Lythrum salicaria
Spiked Lythrum

Panicum capillare
Old Witch Grass

Plantago lanceolata
Plantain

Plantago major
Plantain

Silene noctiflora
Night-flowering Catchfly

Taraxum officinale
Common Dandelion

Trifolium repens
White Clover

Vicia cracca
Hairy vetch

PASTURE

PRINCIPAL SPECIES

Agrostis alba
Redtop Grass

Dactylis glomerata
Orchard Grass

Linaria vulgaris
Butter and Eggs

Polygonum scandens
Climbing False Buckwheat

Setaria glauca
Foxtail Grass

SITE #17 (cont.)

ASSOCIATED SPECIES

Aster linarifolius
Aster

Danthonia spicata
Poverty Grass

Digitaria ischaemum
Small Crab Grass

Glechoma hederacea
Gill-over-the-Round

Rhus typhina
Staghorn Sumac

Viburnum cassinoides
Witherod, Wild-Raisin

SITE #18

This site is primarily forested with the exception of a small meadow in the northeast portion along Prince Valley Road. In some areas the scrub forest has very dense underbrush of scrub oak through which it is difficult to walk. In other areas the forest is open beneath with white oak and bayberry as the dominant species. Along Old Country Road there are open hillsides which are covered with cranberry and downy hudsonia.

MIXED FOREST

PRINCIPAL OVERSTORY SPECIES

Pinus rigida
Pitch Pine

Quercus alba
White Oak

Quercus ilicifolia
Scrub Oak

ASSOCIATED OVERSTORY SPECIES

Quercus coccinae
Scarlet Oak

Quercus velutina
Black Oak

Robinia Pseudo- Acacia
Black Locust

PRINCIPAL UNDERSTORY SPECIES

Myrica pensylvanica
Bayberry, Candleberry

Quercus ilicifolia
Scrub Oak

Vaccinium angustifolium
Lowbush Blueberry

SITE #18 (cont.)

ASSOCIATED UNDERSTORY SPECIES

Acer rubrum
Red Maple

Amelanchier sp.
Shadbush

Arctostaphylos Uva-ursi
Bearberry

Celastrum scandens
Bittersweet

Comptonia peregrina
Sweet Fern

Corema conradii
Broom Crowberry

Gaylussacia dumosa
Dwarf Huckleberry

Hudsonia ericoides
Downy Hudsonia

Prunus serotina
Black Cherry

Quercus alba
White Oak

Robinia Pseudo- Acacia
Black Locust

Rosa virginiana
Rose

Smilax sp.
Greenbriar

Vaccinium vitis - idaea
Northern Mountain Cranberry

PRINCIPAL GROUND COVER SPECIES

Festuca rubra
Fescue

Gaultheria procumbens
Teaberry, Checkerberry

Lycopodium sp.
Club-moss

ASSOCIATED GROUND COVER SPECIES

Aralia nudicaulis
Wild Sarsaparilla

Chimophila umbellata
Pipsessewa

Monotropa uniflora
Indian Pipe

Polytrichum commune
Hairy Cap Moss

Pteridium aquilinum
Bracken Fern

Pyrola rotundifolia
Wild Lily-of-the-Valley

SITE #19

Site Number 19 is almost entirely forested with the exception of a few small areas which have been cleared in the recent past.

MIXED FOREST

PRINCIPAL OVERSTORY SPECIES

Pinus rigida
Pitch Pine

Quercus alba
White Oak

Quercus ilicifolia
Scrub Oak

ASSOCIATED OVERSTORY SPECIES

Betula populifolia
Gray Birch

Populus grandidentata
Bigtooth Aspen

Populus tremuloides
Quaking Aspen

Quercus coccinae
Scarlet Oak

Quercus velutina
Black Oak

PRINCIPAL UNDERSTORY SPECIES

Kalmia angustifolia
Sheep Laurel

Pinus rigida
Pitch Pine

Quercus ilicifolia
Scrub Oak

Smilax glauca
Glaucous Greenbriar

Vaccinium angustifolium
Lowbush Blueberry

SITE #19 (cont.)

ASSOCIATED UNDERSTORY SPECIES

Acer rubrum
Red Maple

Betula populifolia
Gray Birch

Comptonia peregrina
Sweet Fern

Juniperus virginiana
Red Cedar

Populus tremuloides
Quaking Aspen

Prunus serotina
Black Cherry

Quercus alba
White Oak

Quercus prinus
Chestnut Oak

Rhus typhina
Staghorn Sumac

Salix alba
White Willow

Vaccinium atrococcum
Black Highbush Blueberry

Viburnum cassinoides
Witherod, Wild Raisin

Viburnum recognitum
Arrow Wood

PRINCIPAL GROUND COVER SPECIES

Pteridium aquilinum
Bracken Fern

Rubus pubescens
Trailing Rubus

ASSOCIATED GROUND COVER SPECIES

Agropyron repens
Witch Grass

Aristida dichotoma
Poverty Grass

Aster rugosa
Aster

Danthonia spicata
Poverty Grass

Epigala repens
Trailing Arbutus

Gaultheria procumbens
Teaberry, Checkerberry

Mitchella repens
Partridge Berry

Panicum meridionale
Panic Grass

SITE #19 (cont.)

ASSOCIATED GROUND COVER SPECIES (cont.)

Pyrola rotundifolia
Wild Lily-of-the-Valley

CLEARED AREAS

PRINCIPAL SPECIES

Agropyron repens
Witch Grass

Aristida dichotoma
Poverty Grass

Aster linarifolius
Aster

Aster novae-anglii
New England Aster

Cirsium arvense
Canada Thistle

Comptonia peregrina
Sweet Fern

Danthonia spicata
Poverty Grass

Gaultheria procumbens
Teaberry, Checkerberry

Kalmia angustifolia
Sheep Laurel

Lechea maritima
Pinweed

Muhlenbergia uniflora
Grass

Prunus serotina
Black Cherry

Quercus alba
White Oak

Quercus ilicifolia
Scrub Oak

Rubus pubescens
Trailing Rubus

Vaccinium angustifolium
Lowbush Blueberry

Vaccinium atrococcum
Black Highbush Blueberry

SITE #20

This site is primarily forested with the exception of a meadow area at the northern end of the project.

MIXED FOREST

PRINCIPAL OVERSTORY SPECIES

Betula populifolia
Gray Birch

Pinus strobus
Eastern White Pine

Quercus rubra
Red Oak

Tsuga canadensis
Hemlock

ASSOCIATED OVERSTORY SPECIES

Acer rubrum
Red Maple

Betula papyrifera
White Birch

Picea rubens
Red Spruce

Quercus alba
White Oak

Quercus velutina
Black Oak

PRINCIPAL UNDERSTORY SPECIES

Fagus grandifolia
Beech

Kalmia latifolia
Mountain Laurel

Pinus strobus
Eastern White Pine

Tsuga canadensis
Hemlock

Vaccinium angustifolium
Lowbush Blueberry

Viburnum cassinoides
Witherod, Wild Raisin

SITE #20 (cont.)

ASSOCIATED UNDERSTORY SPECIES

Acer rubrum
Red Maple

Betula papyrifera
White Birch

Betula populifolia
Gray Birch

Juniperus communis
Ground Juniper

Picea rubens
Red Spruce

Populus grandidentata
Bigtoothed Aspen

Populus tremuloides
Quaking Aspen

Prunus serotina
Black Cherry

Quercus alba
White Oak

Quercus rubra
Red Oak

Rhododendron roseum
Pink Azalea

Vaccinium corymbosum
Highbush Blueberry

PRINCIPAL GROUND COVER SPECIES

Gaultheria procumbens
Teaberry, Checkerberry

Lycopodium clavatum
Common Club Moss

Pteridium aquilinum
Bracken Fern

ASSOCIATED GROUND COVER SPECIES

Andropogon scoparius
Broom Bear Grass

Aralia nudicaulis
Wild Sarsaparilla

Carex pensylvanica
Sedge

Cornus canadensis
Bunchberry

Cypripedium sp.
Lady's Slipper

Lycopodium complanatum
Trailing Evergreen,
Ground Pine

SITE #20 (cont.)

ASSOCIATED GROUND COVER SPECIES (CONT.)

Lycopodium obscurum
Ground Pine

Mitchella repens
Partridge Berry

Monotropa uniflora
Indian Pipe

Polytrichum commune
Hairy Cap Moss

Pyrola elliptica
Shinleaf

Rubus pubescens
Trailing Rubus

Spiraea latifolia
Meadowsweet

MEADOW AREA

PRINCIPAL TREE AND SHRUB SPECIES

Betula populifolia
Gray Birch

Pinus resinosa
Red Pine

Pinus strobus
Eastern White Pine

Vaccinium angustifolium
Lowbush Blueberry

ASSOCIATED TREE AND SHRUB SPECIES

Acer rubrum
Red Maple

Betula papyrifera
White Birch

Kalmia angustifolia
Sheep Laurel

Pinus rigida
Pitch Pine

Populus grandidentata
Bigtoothed Aspen

Populus tremuloides
Quaking Aspen

Prunus serotina
Black Cherry

Quercus rubra
Red Oak

Viburnum cassinoides
Witherod, Wild Raisin

SITE #20 (cont.)

PRINCIPAL GROUND COVER SPECIES

Gaultheria procumbens
Teaberry, Checkerberry

Pteridium aquilinium
Bracken Fern

Pyrola elliptica
Shinleaf

ASSOCIATED GROUND COVER SPECIES

Andropogon scoparius
Broom Bear Grass

Carex pensylvanica
Sedge

Galuim sp.
Smooth Bedstraw

Mitchella repens
Partridge Berry

Polytrichum commune
Hairy Cap Moss

Potentilla canadensis
Cinquefoil

Rubus pubescens
Trailing Rubus

Spiraea latifolia
Meadowsweet

APPENDIX F

CHECKLIST OF MAJOR PLANT SPECIES ENCOUNTERED AT TWENTY TERRESTRIAL SITES IN NORTHEASTERN MASSACHUSETTS AND CAPE COD

CHECKLIST OF MAJOR PLANT SPECIES ENCOUNTERED AT TWENTY TERRESTRIAL SITES IN NORTHEASTERN MASSACHUSETTS AND CAPE COD

Acer negundo L.
Box Elder, Ashleaf Maple
Fam: *Aceraceae*

Acer pensylvanicum L.
Striped Maple
Fam: *Aceraceae*

Acer plantanoides L.
Norway Maple
Fam: *Aceraceae*

Acer rubrum L.
Red Maple
Fam: *Aceraceae*

Acer saccharum Marsh.
Sugar Maple
Fam: *Aceraceae*

Achillea Millefolium
Yarrow
Fam: *Compositae*

Actaea rubra (Ait.) Willd.
Red Baneberry
Fam: *Ranunculaceae*

Agropyron repens (L.) Beauv.
Witch Grass
Fam: *Gramineae*

Agrostis alba L.
Redtop Grass
Fam: *Gramineae*

Agrostis tenuis Sibth.
Rhode Island Bent Grass
Fam: *Gramineae*

Alnus rugosa (DuRoi) Spreng.
Speckled Alder
Fam: *Corylaceae*

Amarathus retroflexus L.
Amaranth
Fam: *Amarnthaceae*

Ambrosia artemisiifolia L.
Common Ragweed
Fam: *Compositae*

Amelanchier sp.
Shadbush
Fam: *Rosaceae*

Amelanchier canadensis
Shadbush
Fam: *Rosaceae*

Andropogon scoparius Michx.
Broom Bear Grass
Fam: *Gramineae*

Antennaria neglecta Greene
Cudweed
Fam: *Compositae*

Aralia nudicaulis L.
Wild Sarsaparilla
Fam: *Araliaceae*

Arctostaphylos Uva-ursi L. Streng.
Bearberry
Fam: *Ericaceae*

Arisaema atrorubens (Ait.) Blume
Jack-in-the-Pulpit
Fam: *Araceae*

Aristida dichotoma Michx.
Poverty Grass
Fam: *Gramineae*

Asclepias syriaca L.
Common Milkweed
Fam: *Asclepiadaceae*

Aster acuminatus Michx.
Aster
Fam: *Compositae*

Aster cordifolius L.
Aster
Fam: *Compositae*

Aster divaricatus L.
Aster
Fam: *Compositae*

Aster ericoides L.
Aster
Fam: *Compositae*

Aster linarifolius L.
Aster
Fam: *Compositae*

Aster nemoralus Ait.
Aster
Fam: *Compositae*

Aster novae-anglii L.
New England Aster
Fam: *Compositae*

Aster novi-belgii L.
New York Aster
Fam: *Compositae*

Aster virginiensis
Aster
Fam: *Compositae*

Athyrium Filix-femina L.
Lady Fern
Fam: *Polypodiaceae*

Berberis thunbergii DC
Japanese Barberry
Fam: *Berberidaceae*

Berberis vulgaris L.
Barberry
Fam: *Berberidaceae*

Betula alleghaniensis Britt
Yellow Birch
Fam: *Corylaceae*

Betula lenta L.
Black Birch
Fam: *Corylaceae*

Betula papyrifera Marsh.
White Birch
Fam: *Corylaceae*

Betula populifolia
Gray Birch
Fam: *Corylaceae*

Botrychium dissectum Spreng
Grape Fern
Fam: *Ophioglossaceae*

Carex sp.
Sedge
Fam: *Cyperaceae*

Carex communus Bailey
Sedge
Fam: *Cyperaceae*

Carex crinita Lam
Sedge
Fam: *Cyperaceae*

Carex debilis Michx.
Sedge
Fam: *Cyperaceae*

Carex folliculata L.
Sedge
Fam: *Cyperaceae*

Carex laxiculmis Schwein
Sedge
Fam: *Cyperaceae*

Carex pensylvanica Lam.
Sedge
Fam: *Cyperaceae*

Carex virginiana Fern.
Sedge
Fam: *Cyperaceae*

Carya sp.
Hickory
Fam: *Juglandaceae*

Carya cordiformis (Wang.) K. Koch
Bitternut Hickory
Fam: *Juglandaceae*

Carya ovalis (Wang.) Sarg.
Sweet Pignut Hickory
Fam: *Juglandaceae*

Carya ovata (Mill.) K. Koch
Shagbark Hickory
Fam: *Juglandaceae*

Castanea dentata Marsh.
Chestnut
Fam: *Fagaceae*

Celastrus scandens L.
Bittersweet
Fam: *Celastraceae*

Chelone glabra L.
Turtlehead
Fam: *Scrophulariaceae*

Chenopodium album L.
Pigweed
Fam: *Chenopodiaceae*

Chimaphila maculata L. (Porsh.)
Pipsessewa
Fam: *Pyrolaceae*

Chimaphila umbellata (L.) Bart.
Pipsessewa
Fam: *Pyrolaceae*

Chrysanthemum lecanthum L.
Daisy
Fam: *Compositae*

Cirsium arvense (L.) Scop.
Canada Thistle
Fam: *Compositae*

Comptonia peregrina L. Coult.
Sweet Fern
Fam: *Myricaceae*

Coptis groenlandica (Oeder) Fern.
Goldthread
Fam: *Ranunculaceae*

Corema conradii Torr.
Broom - Crowberry
Fam: *Limnanthaceae*

Cornus amomum Mill.
Silky Dogwood
Fam: *Cornaceae*

Cornus canadensis L.
Bunchberry
Fam: *Cornaceae*

Cornus florida L.
Flowering Dogwood
Fam: *Cornaceae*

Cornus stolonifera Michx.
Red-Osier Dogwood
Fam: *Cornaceae*

Corylus americana Walt.
American Hazlenut
Fam: *Corylaceae*

Cyanthus nigrum (L.) Pers.
Climbing Milkweed
Fam: *Asclepiadaceae*

Cyperus esculentis L.
Sedge
Fam: *Cyperaceae*

Cypripedium sp.
Lady's Slipper
Fam: *Orchidaceae*

Dactylis glomerata L.
Orchard Grass
Fam: *Gramineae*

Danthonia spicata (L.) Beauv.
Poverty Grass
Fam: *Gramineae*

Daucus carota L.
Wild Carrot, Queen Anne's Lace
Fam: *Umbelliferae*

Dennstaedtia punctilobula Michx.
Hayscented Fern
Fam: *Polypodiaceae*

Digitaria Ischaemum (Shreb.) Muhl.
Small Crab Grass
Fam: *Gramineae*

Dryopteris spinulosa Watt
Spinulose Wood Fern
Fam: *Polypodiaceae*

Echinochloa crusgalli (L.) Beauv.
Barnyard Grass
Fam: *Gramineae*

Eleocharis obtusa (Willd.) Schultes
Spikerush
Fam: *Cyperaceae*

Elymus canadensis L.
Wild Rye
Fam: *Gramineae*

Epifagus virginiana (L.) Bart.
Beech-drops
Fam: *Grobanchaceae*

Epigaea repens L.
Trailing Arbutus
Fam: *Ericaceae*

Eragrostis spectabilis Pursh.
Tumble Grass
Fam: *Gramineae*

Eupatorium purpureum L.
Joe Pye-weed
Fam: *Compositae*

Euphorbia esula L.
Wolf's Milk, Leafy Spurge
Fam: *Euphorbiaceae*

Fagus grandifolia Ehrh.
Beech
Fam: *Fagaceae*

Festuca capillata Lam.
Fescue
Fam: *Gramineae*

Festuca rubra L.
Fescue
Fam: *Gramineae*

Fraxinus americana L.
White Ash
Fam: *Oleaceae*

Galium sp.
Smooth Bedstraw
Fam: *Rubiaceae*

Galium sylvaticum L.
Baby's Breath
Fam: *Rubiaceae*

Gaultheria procumbens L.
Teaberry, Checkerberry
Fam: *Ericaceae*

Gaylussacia baccata (Wang.) K. Koch
Black Huckleberry
Fam: *Ericaceae*

Gaylussacia dumosa Andr. T. E. G.
Dwarf Huckleberry
Fam: *Ericaceae*

Gentiana clausa Raf.
Closed Gentian
Fam: *Gentianaceae*

Gerardia purpurea L.
Gerardia
Fam: *Scrophulariaceae*

Glechoma sp.
Creeping Jenny
Fam: *Labiatae*

Glechoma hederacea L.
Gill-over-the-Round
Fam: *Labiatae*

Glenditsia triacanthos L.
Honey Locust
Fam: *Leguminosae*

Gnaphalium obtusifolium L.
Cudweed, Everlasting
Fam: *Compositae*

Goodyera tesselata Lodo.
Rattlesnake Plantain
Fam: *Orchidaceae*

Hamamelis virginiana L.
Witch Hazel
Fam: *Hamamelidaceae*

Hieracium praealtum Koch
King Devil
Fam: *Compositae*

Hordeum sp.
Barley
Fam: *Gramineae*

Hudsonia ericoides L.
Downy Hudsonia
Fam: *Cistaceae*

Hypericum sp.
St. John's-Wort
Fam: *Guttiferae*

Hypericum perforatum L.
St. John's-Wort
Fam: *Guttiferae*

Ilex laevigata (Pursh.) Gray
Smooth Winterberry
Fam: *Aquifoliaceae*

Ilex verticillata (L.) Gray
Winterberry, Black Alder
Fam: *Aquifoliaceae*

Impatiens capensis (DuRoi) Spreng.
Touch-Me-Not
Fam: *Balsaminaceae*

Juglans cinerea L.
Butternut, White Walnut
Fam: *Juglandaceae*

Juncus sp.
Rush
Fam: *Juncaceae*

Juncus effuses L.
Soft Rush
Fam: *Juncaceae*

Juniperus communis L.
Ground Juniper
Fam: *Pinaceae*

Juniperus virginiana L.
Red Cedar
Fam: *Pinaceae*

Kalmia latifolia L.
Mountain Laurel
Fam: *Ericaceae*

Larix laricina (DuRoi) K. Koch
Tamarack
Fam: *Pinaceae*

Lechea maritima Leggett.
Pinweed
Fam: *Cistaceae*

Leontodon sp.
Wild Dandelion
Fam: *Compositae*

Leontodon autumnalis L.
Fall Dandelion
Fam: *Compositae*

Linaria vulgaris Hill
Butter and Eggs
Fam: *Scrophulariaceae*

Lonicera villosa Michx.
Honeysuckle
Fam: *Caprifoliaceae*

Lycopodium sp.
Club Moss
Fam: *Lycopodiaceae*

Lycopodium clavatum L.
Common Club Moss
Fam: *Lycopodiaceae*

Lycopodium complanatum L.
Trailing Evergreen, Ground Pine
Fam: *Lycopodiaceae*

Lycopodium obscurum L.
Ground Pine
Fam: *Lycopodiaceae*

Lythrum salicaria L.
Loosestrife
Fam: *Lythraceae*

Maianthemum canadense Desf.
Canada Mayflower
Fam: *Liliaceae*

Medeola virginiana L.
Indian Cucumber
Fam: *Liliaceae*

Medicago sativa L.
Alfalfa
Fam: *Leguminosae*

Mentha sp.
Mint
Fam: *Labiatae*

Mentha piperita L.
Peppermint
Fam: *Labiatae*

Mitchella repens L.
Partridge Berry
Fam: *Rubiaceae*

Monotropa Hypopithys L.
Pinesap
Fam: *Pyrolaceae*

Monotropa uniflora L.
Indian Pipe
Fam: *Pyrolaceae*

Muhlenbergia tenuiflora
(Muhl.) Fern
Grass
Fam: *Gramineae*

Muhlenbergia uniflora
(Muhl.) Fern
Grass
Fam: *Gramineae*

Myrica pensylvanica Loisel.
Bayberry, Candleberry
Fam: *Melastromataceae*

Nyssa sylvatica Marsh.
Sourgum, Black Gum
Fam: *Melastomataceae*

Onoclea sensibilis L.
Sensitive Fern
Fam: *Polypodiaceae*

Osmunda cinnamomea L.
Cinnamon Fern
Fam: *Osmundaceae*

Osmunda claytonia
Interrupted Fern
Fam: *Osmundaceae*

Osmunda regalis L.
Royal Fern
Fam: *Osmundaceae*

Ostrya virginia (Mill.) K. Koch
Hornbeam
Fam: *Corylaceae*

Oxalis corniculata L.
Wood Sorrel
Fam: *Oxalidaceae*

Panicum capillare L.
Old Witch Grass
Fam: *Gramineae*

Panicum meridionale Ashe
Panic Grass
Fam: *Gramineae*

Panicum oligosanthes Schultes
Panic Grass
Fam: *Gramineae*

Parthenocissus quinquefolia (L.) Planch.
Virginia Creeper
Fam: *Vitaceae*

Phalaris arundinacea L.
Reed Canary Grass
Fam: *Gramineae*

Phleum pratense L.
Timothy
Fam: *Gramineae*

Phytolacca americana L.
Pokeweed
Fam: *Phytolaccaceae*

Picea abies (L.) Karst.
Norway Spruce
Fam: *Pinaceae*

Picea rubens Sarg.
Red Spruce
Fam: *Pinaceae*

Pinus resinosa Ait.
Red, Norway Pine
Fam: *Pinaceae*

Pinus rigida Mill.
Pitch Pine
Fam: *Pinaceae*

Pinus strobus L.
Eastern White Pine
Fam: *Pinaceae*

Plantago lanceolata L.
Plantain
Fam: *Plantaginaceae*

Plantago major L.
Plantain
Fam: *Plantaginaceae*

Poa pratensis L.
Kentucky Bluegrass
Fam: *Gramineae*

Polygonatum pubescens (Willd.) Pursh.
True Solomon's Seal
Fam: *Liliaceae*

Polygonum sp.
Smartweed
Fam: *Polygonaceae*

Polygonum aviculare L.
Knotweed
Fam: *Polygonaceae*

Polygonum persecaria L.
Lady's Thumb
Fam: *Polygonaceae*

Polygonum scandens L.
Climbing False Buckwheat
Fam: *Polygonaceae*

Polystichum acrosticoides (Michx.) Schott
Christmas Fern
Fam: *Polypodiaceae*

Polytrichum commune
Hairy Cap Moss
Fam: *Polytrichaceae*

Potentilla sp.
Cinquefoil
Fam: *Rosaceae*

Potentilla canadensis L.
Cinquefoil
Fam: *Rosaceae*

Potentilla norvegica Fern
Cinquefoil
Fam: *Rosaceae*

Potentilla simplex Fern
Cinquefoil
Fam: *Rosaceae*

Populus grandidentata Michx.
Bigtoothed Aspen
Fam: *Salicaceae*

Populus tremuloides Michx.
Quaking Aspen
Fam: *Salicaceae*

Prenanthes trifoliata (Cass.) Fern
Gall-of-the-Earth
Fam: *Compositae*

Prunella vulgaris L.
Selfheal
Fam: *Labiatae*

Prunus serotina Ehrh.
Black Cherry
Fam: *Rosaceae*

Pseudotsuga Menzeseii (Beissn.) Franco
Douglas Fir
Fam: *Pinaceae*

Pteridium aquilinum (L.) Kuhn
Bracken Fern
Fam: *Polypodiaceae*

Pyrola elliptica Nutt.
Shinleaf
Fam: *Pyrolaceae*

Pyrola rotundifolia L.
Wild-Lily-of-the-Valley
Fam: *Pyrolaceae*

Pyrus sp.
Chokeberry
Fam: *Rosaceae*

Pyrus arbutifolia
Red Chokeberry
Fam: *Rosaceae*

Pyrus communis L.
Pear
Fam: *Rosaceae*

Pyrus malus L.
Apple
Fam: *Rosaceae*

Pyrus melanocarpa
(Michx.) Willd.
Black Chokeberry
Fam: *Rosaceae*

Quercus alba L.
White Oak
Fam: *Fagaceae*

Quercus bicolor Willd.
Swamp White Oak
Fam: *Fagaceae*

Quercus coccinae Muechh.
Scarlet Oak
Fam: *Fagaceae*

Quercus ilicifolia Wang.
Scrub Oak
Fam: *Fagaceae*

Quercus prinus L.
Chestnut Oak
Fam: *Fagaceae*

Quercus rubra L.
Red Oak
Fam: *Fagaceae*

Quercus velutina Lam.
Black Oak
Fam: *Fagaceae*

Rhamnus frangula L.
Alder Buckthorn
Fam: *Rhamnaceae*

Rhododendron roseum Loisel
Pink Azalea
Fam: *Ericaceae*

Rhus glabra L.
Smooth Sumac
Fam: *Anacardiaceae*

Rhus radicans L.
Poison Ivy
Fam: *Anacardiaceae*

Rhus typhina L.
Staghorn Sumac
Fam: *Anacardiaceae*

Robinia Pseudo-Acacia L.
Black Locust
Fam: *Leguminosae*

Rosa sp.
Rose
Fam: *Rosaceae*

Rosa virginiana Mill.
Rose
Fam: *Rosaceae*

Rubus sp.
Raspberry
Fam: *Rosaceae*

Rubus idaeus L.
Red Raspberry
Fam: *Rosaceae*

Rubus pubescens Raf.
Trailing rubus
Fam: *Rosaceae*

Rubus setosos Bigel.
Bristly blackberry
Fam: *Rosaceae*

Rudbeckia serotina Nutt.
Black Eyed Susan
Fam: *Compositae*

Salix sp.
Willow
Fam: *Salicaceae*

Salix alba L.
White Willow
Fam: *Salicaceae*

Sassafras albidum (Nutt.) Nees
White Sassafras
Fam: *Lauraceae*

Scirpus atrovirens Willd.
Bulrush
Fam: *Cyperaceae*

Setaria glauca L. (Beauv.)
Foxtail Grass, Pigeon Grass
Fam: *Gramineae*

Silene noctiflora L.
Night-flowering Catchfly
Fam: *Caryophyllaceae*

Smilacina racemosa (L.) Desf.
False Solomon's Seal
Fam: *Liliaceae*

Smilax sp.
Greenbriar
Fam: *Liliaceae*

Smilax glauca Walt.
Glaucous Greenbriar
Fam: *Liliaceae*

Smilax herbacea L.
Carrion Flower
Fam: *Liliaceae*

Smilax rotundifolia L.
Smilax
Fam: *Liliaceae*

Solanum carolinease L.
Horse-nettle
Fam: *Solanaceae*

Solanum dulcamara L.
Nightshade
Fam: *Solanaceae*

Solidago sp.
Goldenrod
Fam: *Salicaceae*

Solidago bicolor L.
Silver Rod
Fam: *Salicaceae*

Solidago caesia L.
Goldenrod
Fam: *Salicaceae*

Solidago gigantea Ait.
Goldenrod
Fam: *Salicaceae*

Solidago graminifolia (L.) Salisb.
Goldenrod
Fam: *Salicaceae*

Solidago nemoralis Ait.
Goldenrod
Fam: *Salicaceae*

Solidago rugosa Ait.
Goldenrod
Fam: *Salicaceae*

Spellaria graminea
Stitchwort
Fam: *Carophyllaceae*

Spiraea latifolia (Ait.) Borkh.
Meadowsweet
Fam: *Rosaceae*

Spiraea tomentosa L.
Meadowsweet
Fam: *Rosaceae*

Tanacetum vulgare L.
Common Tansy, Golden-Buttons
Fam: *Compositae*

Taraxum officinale Weber
Common Dandelion
Fam: *Compositae*

Thalictrum polyganum Muhl.
Tall Meadow Rue
Fam: *Ranunculaceae*

Tilia americana L.
Basswood
Fam: *Tiliaceae*

Trientalis borealis Raf.
Starflower
Fam: *Primulaceae*

Trifolium pratense L.
Red Field Clover
Fam: *Leguminosae*

Trifolium repens L.
White Clover
Fam: *Leguminosae*

Tsuga canadensis (L.) Carr.
Eastern Hemlock
Fam: *Pinaceae*

Ulmus americana L.
American Elm
Fam: *Ulmaceae*

Ulmus rubra Muhl.
Slippery Elm
Fam: *Ulmaceae*

Vaccinium angustifolium Ait.
Lowbush Blueberry
Fam: *Ericaceae*

Vaccinium atrococcum (Gray) Heller
Black Highbush Blueberry
Fam: *Ericaceae*

Vaccinium corymbosum L.
Highbush Blueberry
Fam: *Ericaceae*

Vaccinium vascillans Torr.
Sugar Huckleberry
Fam: *Ericaceae*

Vaccinium vitis-idaea Lodd.
Northern Mountain Cranberry
Fam: *Ericaceae*

Verbascum sp.
Mullein
Fam: *Scrophulariaceae*

Viburnum sp.
Viburnum
Fam: *Caprifoliaceae*

Viburnum acerifolium L.
Mapleleaf Viburnum
Fam: *Caprifoliaceae*

Viburnum alnifolium L.
Dockmackie
Fam: *Caprifoliaceae*

Viburnum cassinoides L.
Witherod, Wild Raisin
Fam: *Caprifoliaceae*

Viburnum recognitum Fern
Arrow-wood
Fam: *Caprifoliaceae*

Vicia cracca L.
Hairy Vetch
Fam: *Leguminosae*

Vinca minor L.
Periwinkle
Fam: *Apocynaceae*

Viola sp.
Violet
Fam: *Violaceae*

Viola lanceolata L.
Lance-leaved Violet
Fam: *Violaceae*

Vitis sp.
Grape (Vine)
Fam: *Vitaceae*

APPENDIX G

HABITAT REQUIREMENTS OF PRINCIPAL PLANT SPECIES AT TWENTY TERRESTRIAL SITES IN NORTHEASTERN MASSACHUSETTS AND CAPE COD

I. OVERSTORY

ACERACEAE

Acer rubrum (red maple) -- The range of red maple is restricted by extreme cold climate in the north and dry climate in the west. It is common, rapid growing and widely distributed. It can be found in nearly all variations of podzol, alluvial, bog, lithosols and shallow soils. Glaciated and unglaciated soils support it. Despite its ability to grow in many types of soils and moisture conditions from swamps to mountain ridges, red maple is more common where extreme dry or wet soil conditions occur. On the periphery of its range red maple is best developed in river beds and similar low, wet sites.

Acer saccharum (sugar maple) -- An upland species, it is found primarily on rich, well-drained, rocky soils of slopes and hills but can grow in poorly drained rocky soils. It grows on podzols, gray podzols, gray brown podzols, loamy sand, sandy loam, loam and silt loam. This tree grows best on loam especially those which are underlayed with limestone. Sugar maple has a wide pH range but it is more common on soils with pH from 5.5 to 7.3. Generally, the yield and quality of the species improves with increasing fertility and moisture content of the soil.

CORYLACEAE

Betula lenta (black birch) -- typically an upland tree. It grows in podzols, brown podzols and does best in gray brown podzols. Although this birch does best in deep, moist soil it is often found in coarse or shallow soils or dryer, rocky or gravelly slopes.

Betula papyrifera (white birch) -- a cold climate species which is able to tolerate a wide range of precipitation. It is most abundant in New England growing on podzols, brown podzols, gray brown podzols and well-drained sandy loams. White birch thrives on moist sites around various water bodies but also grows on drier soils of mountain slopes and hillsides. White

birch is a light tolerant species and grows quickly in old fields and clearings to yield a temporary stand.

Betula populifolia (gray birch) -- a short lived tree which rapidly establishes itself on the poorest of soils. It is found on poor sandy soils, gravelly uplands as well as wet soils along water bodies. It aggressively invades old fields and burned areas. It grows only in the open and since it is an intolerant species it is quickly succeeded by other hardwoods and pines.

FAGACEAE

Fagus grandifolia (beech) -- a common tree throughout New England. Beech is a mesophytic species using about 10 inches of water for transpiration and growth annually. Within the range of beech annual precipitation is usually from 30 - 50 inches. Soils of loamy texture and those with a high humus content are more favorable than lighter soils. The largest trees are found in alluvial bottom lands. It will grow on poorly drained sites not subject to prolonged flooding and may grow where the water table is 6 - 10 inches from the surface. Beech trees growing on poorly drained sites have shallower root systems than on better sites. Beech is found on soils with a pH ranging from 4.1 - 6.0 but seldom on soils exceeding pH 7.0.

Quercus alba (white oak) -- one of the largest and most valuable forest trees. It grows best in rich moist soils at lower elevations. White oak seldom grows above 500 feet in elevation. White oak grows on most podzols, lithosols, planothols and alluviums from glaciated and nonglaciated soils. It grows well on most soils except those which are extremely shallow, wet or dry. Best growth occurs on northerly and easterly slopes. It is rarely mixed with conifers or found in pure stands. Mineral nutrition does not limit white oak growth except in very sandy soils. Apparently this tree can assimilate sufficient minerals from even the poorer soils.

Quercus coccinea (scarlet oak) -- an upland tree found in humid regions where precipitation ranges from 30 - 55 inches per year. It is found mostly in the gray brown podzols of the north, and the southern yellow and red podzols. Competition and regeneration of scarlet oak is best in poor, sandy or

gravelly soils, but site index increases with increasing depth of Horizon A, decreasing sand content of Horizon A and lower position on the slope. Slope gradient and depth of soil above bedrock are also important.

Quercus ilicifolia (scrub oak) -- a species which thrives on the poorest of soils. It is found on dry, infertile sands along the coast, on barren mountain tops, rocky slopes and areas which have been burned over. It is an important cover species for those infertile areas which cannot support more demanding trees. Scrub oak is shade intolerant and thus is dependent on fires for its perpetuation.

Quercus rubra (red oak) -- is the most widely distributed, fastest growing and tallest of the New England oaks. It is found where annual precipitation is between 30 to 80 inches. It grows on most well-drained soils from clay, to loamy, to shallow rocky. Soil depth and amount of available soil moisture affect site quality. Best sites have fine textured soils and a subsoil strata favoring a high water table. Red oak is found on lower and middle elevations primarily on northerly and easterly slopes and in valleys.

Quercus velutina (black oak) -- is typical of dry rocky or gravelly slopes and ridges. It occurs on heavy, glaciated hillsides but does best in the lower slopes and unglaciated coves. Black oak can develop on dry sites because it has the ability of sending down long tap roots. It is sensitive to too much moisture. Black oak growth is optimum in areas with precipitation ranging from 40 to 50 inches per year.

JUGLANDACEAE

Carya cordiformis (bitternut hickory) -- the most abundant and widely distributed of the hickories but it is of minor economic importance in hardwood forests. It occurs where the growing season ranges from 120 to 240 days. A bottomland tree, it grows best on moist, rich, loamy or gravelly soil. It is commonly found in old fields, along slow moving streams and swamps. It also grows well on poor, dry soils of slopes.

Carya ovalis (sweet pugnut hickory) -- an upland species which grows best on well drained to dry, fairly rich soils on hillsides and ridges. It grows in a humid climate where annual rainfall is 30 - 80 inches. This species responds readily to increases in soil fertility.

Carya ovata (shagbark hickory) -- grows best on rich, moist well-drained but not wet loams. It is found in bottomlands and rocky slopes to an elevation of 2,000 feet. Shagbark hickory thrives best in the deep, moist alluvial soils.

OLEACEAE

Fraxinus americana (white ash) -- grows best in deep, rich, non-acidic loams and does poorly in sandy, gravelly soils. White ash has a pH tolerance which varies from 5.0 to 7.5. It thrives where soil is moist and moderately well-drained. It is found in gray brown podzol and brown podzol soils. It is found almost exclusively in bottomlands where the site is underlain by compacted glacial till, which can support a perched water table during periods of high precipitation. It is commonly found on fertile soils with a high nitrogen content and a moderate to high calcium content.

PINACEAE

Pinus resinosa (red pine) -- thrives on dry, gravelly and sandy soils. It does not do well in low, wet areas or where it is on hardpan or heavy lacustrine soil. Natural stands occur only where podzols exist (melanized sands, podzol sands, sandy podzols and well-drained gray-podzol soils). Although red pine doesn't grow when surface soil is alkaline, it can be found on well-drained limestone or calcerous soil which has an overlayer of dry acid soil. It is also found on rocky outcrops with organic debris and red clays. Red pine grows well on soil with pH between 4.5 to 6.0, a silt-plus-clay content of 10 to 40 percent, a cation exchange capacity of 2 to 11 m.e. per 100g., and organic content of at least 1.7%, total nitrogen content of 0.03 to 0.04%. and available P_2O_5 of 40 to 60 pounds per acre and K_2O of 40 to 200 pounds per acre. Strong concentration of iron and humus in the B-horizon seem to be adverse for red pine.

Pinus rigida (pitch pine) -- is associated with poorer soils. It grows well in sandy, gravelly textured, acid podzols, podzols, brown podzols and gray brown podzol soils. It is found on sandy coastal plains, river valleys, and rocky ridges. Pitch pine can withstand fire better than most trees and it can grow in the shallow soil of hillsides and ridges. Where soil is very dry or sterile, pitch pine is characterized by short and scrubby growth. It is most commonly found along the coast or in river valleys. Pitch pine is often associated with scrub oak.

Pinus strobus (eastern white pine) -- is found in cool, humid climates. It grows on most soils but is more commonly associated with well-drained loams and sandy or silty soils where there is little hardwood competition during the establishment period. Eastern white pine is usually found in the overstory of a mixed forest but sometimes forms pure stands. The "normal" root system has only the vestige of a tap root. The tree is anchored by several large downward spreading lateral roots. Only when soils are deep and coarse textured are deep sinker roots formed by the lateral branches.

Tsuga canadensis (eastern hemlock) -- is most productive in cool and humid climates where annual precipitation ranges from 32 - 36 inches. It is the most shade enduring conifer and best development occurs in dense forest conditions. In New England it is found on rocky, acid to near neutral soils, on loam and on silt loams. It also grows well on rocky slopes as well as edges of swamps. It is a moisture tolerant species and thus is shallow rooted and subject to windfall. It often forms an understory in hardwood and white pine forests. When established, its dense canopy forms a micro-climate which is much cooler and moister than that under a hardwood forest. The litter of established hemlock is highly acidic and causes leaching of the upper soil horizons. When conditions are favorable, hemlock can form a climax stand.

ROSACEAE

Pyrus malus (apple) -- grows best in climates where the daily temperature range does not exceed 20°C. Good drainage as well as adequate water supply are important to proper development. Apple is best adapted to deep, friable, loamy soil

which is conducive to the maintenance of an adequate water reservoir and the development of an adequate root system. A subsoil depth of 6 to 8 feet and fine textured soil are essential, especially where dry periods occur. Apple roots develop poorly where soil is too wet, too shallow and where hardpan and ledge exist. In the northern regions of its range, apple does best on north and northeastern slopes where there is a tendency for retarded growth in spring (which minimizes the danger of frost injury).

Nitrogen, phosphorus and potash are important fertilizers. Research has shown that good growth occurs with a ratio of 30 lbs. actual N, 50 lbs. actual phosphoric acid (P_2O_5) and 25 to 50 lbs. actual potash (K_2O) per acre. Nitrogen produces strong vegetative growth and retards maturity and ripening of fruit. Phosphorus is required for new growth and root formation. Apple does not require a constant (yearly) input of fertilizer.

ULMACEAE

Ulmus americana (American elm) -- is found in a wide variety of habitats but is most common in bottomlands and wet areas. Growth is poor in droughty sands and on sites with high summer water tables. It is found on the brown podzols of New England and on most podzols, planozols, alluvial and bog soils. However, organic soils are usually poor sites for elm. It grows in coarse sand to clay sites but does best on well-drained loam. Its pH range is 5.5 to 8.0. Elm is a good soil builder because its litter is high in nutrients (potassium and calcium) and decomposes rapidly.

II. UNDERSTORY AND GROUNDCOVER SPECIES

AMARANTHACEAE

Amaranthus retroflexus (Amaranth) -- found where the ground is not already occupied by sod. Established wherever agricultural seeds are planted in suitable ground. The weed does not thrive in shade but in sunny areas it competes too success-

fully with plants of economic value. In July and August it serves as the host to the stalk borer, *Papaipema nitela* and larva of the skipper butterfly, *Pholisora catullus*. Provides abundant food and shelter for winter birds. Sometimes accumulates excess nitrites causing cattle that eat the weed to bloat. The plant is not particularly favored by grazing animals, however, because of the tough stalk and stiff bracts.

ARALIACEAE

Aralia nudicaulis (wild sarsaparilla) -- found in rocky or sandy open woods and edges of clearings.

CAPRIFOLIACEAE

Viburnum acerifolium (mapleleaf Viburnum) -- occurs most often on dry to well drained, wooded slopes. It is a frequent understory shrub in deciduous forests. The soil is usually quite thin where this plant is abundant.

Viburnum recognitum (smooth arrowwood) -- found in damp places, such as swamps and along borders of streams and lakes, but grows well in any moist, rich woodland soil.

COMPOSITAE

Achilea millefolium (yarrow) -- yarrow is relatively tolerant of heat, cold, and drought. It persists mainly on soil too thin for favorable growth of more desirable plants. As a weed it is easily controlled by cultivation. Cattle eating it may yield bitter tasting milk. Where it grows profusely it is usually avoided by grazing animals because of the taste.

Ambrosia artemisifolia (ragweed) -- while this weed is one of the major sources of pollen that causes hay fever, the fruits form a major winter food for the ruffed grouse and bobwhite quail. The plant harbors a borer in the stalk with a wasp like parasite which destroys the oriental fruit moth, a

serious peach orchard pest. Soil requirements of this weed are minimal.

Aster acuminatus (pointed-leaved aster) -- this aster is found particularly in dense deciduous woods.

Aster ericoides (white heath aster) -- found bordering dry fields, seasides.

Aster novae-anglii (New England aster) -- found under relatively moist conditions, in waste places and abandoned fields where drainage is poor. The plant is also found along swamp borders.

Solidago bicolor (silver rod) -- found in dry soil, frequently in the shade of woodlands or thickets, not as common in the open.

Solidago graminifolia (goldenrod) -- found on moist and dry, gravelly and clayey soils, in thickets and near the shores of large bodies of water.

Taraxacum officinale (dandelion) -- this familiar weed, introduced from Europe, is mainly a pest in lawns. It is often an impurity in bluegrass and forage grass seeds.

ERICACEAE

Gaultheria procumbens (teaberry) -- found in woodlands (particularly coniferous) on acid soils. Requires moist soil and partial shade. Teaberry thrives under the same conditions which support mosses.

Kalmia angustifolia (sheep laurel) -- found in moist open areas, bogs and rocky or sandy forested areas. Prefers acidic soils.

Kalmia latifolia (mountain laurel) -- common forest species growing on dry sandy soil and rocky ridges. Grows most profusely where soil is too poor or dry for other plants to compete.

Vaccinium angustifolium (lowbush blueberry) -- found on dry hillsides, chiefly in poor, rocky, acid soils, especially on abandoned pasture lands.

Vaccinium corymbosum (highbush blueberry) -- found in damp rocky woods, swampy places, bogs and low wet ground. It also invades abandoned fields and pasture lands which are poorly drained.

FAGACEAE

Castanea dentata (chestnut) -- mature specimens of this tree are rare, the species having suffered heavily from the attacks of a fungus (*Endothia parasitica*). Once a codominant in the overstory, the shoots of this tree are still associated with maple-beech forest types. The saplings or "suckers" are typically found on hillsides or lower slopes on relatively poor, well drained soils.

GRAMINEAE

Agrostis alba (redtop grass) -- an important meadow grass, also used in lawn seed mixtures. This grass has escaped extensively to waste ground, roadsides, etc. Forms a sod more quickly than bluegrass and lives on soils too heavy, wet or acid for many other grasses to survive.

Agrostis tenuis (Rhode Island bent grass) -- cultivated as a lawn and pasture grass, may escape and establish itself in abandoned areas.

Andropogon scoparius (broom bear-grass) -- found under dry conditions, including sandy, stony and thin rocky soils. Also called "little bluestem" this grass furnishes grazing for cattle and horses in western portions of its range.

Dactylis glomerata (orchard grass) -- this grass, introduced from Europe thrives in the climate of eastern Massachusetts. It will tolerate partial shade. Seed is produced commercially in Kentucky. The grass is good for early pasture and excellent for hay. It does not stand close grazing well.

Danthonia spicata (poverty grass) -- one of the few native forage grasses still abundant. Presence of the plant indicates soil exhaustion; the cleaner the stand, the more "worn-out" the soil. The index applies equally to rocky, sandy or clayey soils. Does very poorly on rich soils where it must compete with a host of other plants. This grass may be most abundant in hilly portions of the site where excessive drainage and acid conditions perpetuate rather sterile soil condition.

Eragrostis spectabilis (tumble grass) -- found on dry sandy soil, on open ground.

Festuca capillata (hair fescue) -- a fescue grass introduced from Europe, it occurs in lawns and waste places having been mixed with taller more desirable fescues. Fescue grasses are well adapted to the relatively cool climate of this area.

Phleum pratense (timothy grass) -- this species is an important meadow grass which is widely cultivated and is often found growing wild. It is found in cool, humid climates; its range is limited by heat and drought. This grass is very cold resistant and overwinters well. It grows best in heavy clay and loam soils which are moist but well drained.

Poa pratensis (Kentucky bluegrass) -- found in open woods as well as meadows and humid pastures. This grass does best on soils with lime. Commonly cultivated for lawns and pasture, it is one of the best forage grasses.

Setaria glauca (foxtail grass) -- found in cultivated land and waste places where the soil is loose or disturbed. Introduced from Europe probably as an impurity with commercially valuable seed. Cattle will eat young shoots but mature plants are worthless as fodder. Seeds projecting above the snow provide acceptable food for game birds and other over wintering species.

This plant favors rich soils (e.g. fertilized).

LEGUMINOSAE

Trifolium pratense (red clover) -- widely cultivated in the United States particularly for hay. Grows well on dry relatively impoverished soil but does not tolerate highly acid conditions. It is difficult to get a good crop if soil is very damp.

Vicia cracca (hairy vetch) -- found on gravelly or sandy soils, usually entwined in dense thickets of grasses.

LYCOPODIACEAE

Lycopodium clavatum (common club moss) -- found in open fields or woods or mixed with grasses on soil too poor or sterile to support other plants. Soils must, however, be relatively free of lime. May do well on sand or gravels where there is little competition from other plants.

Lycopodium complanatum (trailing evergreen) -- found in open woodlands or on dry gravelly banks. Tolerates acid soil but not alkaline.

Lycopodium obscurum (ground pine) -- found in deciduous woods, on shady slopes, sometimes in wet pastures or rocky wooded swamps. Some botanists recognized two varieties, one inhabiting edges of clearings and the other in more shaded conditions.

MYRICACEAE

Comptonia peregrina (sweet fern) -- this shrub is abundant on dry, sandy, sterile soils where it forms low, mat-like thickets. Frequently it is one of the first plants to invade burned over areas and abandoned fields. The shrub has been used on banks along some highways to help keep the soil from washing. Acid soils and full sunlight are most suitable for the plant. It does not grow well in limestone soils. It can also grow in wet spots.

ORCHIDACEAE

Cypripedium sp. (lady's slipper) -- found mostly in wooded swamps and wet woodlands. Most species also thrive on shaded hillsides in company with ferns and lichens. The yellow lady's slipper (*c. calceolus*) is usually associated with maple beech type forests. The pink lady's slipper *(c. acaule)* will tolerate relative dryness on exposed hillsides.

OXALIDACEAE

Oxalis corniculata (wood sorrel) -- found on moderately well drained to excessively drained gravelly and sandy soils. Does not do well if the soil is very wet. As a weed it is easily controlled through cultivation.

PINACEAE

Juniperus communis (common juniper) -- grows well on the poorest and driest, sandy, stony or rocky soils. In some places it may become an agressive pasture weed. The ground juniper is a prostrate variety (*J. communis* var. *depressa)*.

POLYPODIACEAE

Dennstaedtia punctilobula (hayscented fern) -- usually found in dry woods or rocky slopes, hillside pastures, meadows and stony fields, only rarely in swamps. Prefers slightly acid soil. Very sensitive to early frosts.

Pteridium aquilinum (bracken fern) -- found in open woods, stream margins, banks and slopes, upland pastures and abandoned fields. Most common where the soil is dry, sandy or sterile and gravelly. Tolerates neutral to strong acid conditions.

POLYTRICHACEAE

Polytrichium commune (hair cap moss) -- found on damp soil, common along margins of marshes, ponds or lakes. While this plant thrives in wet situations the places where it grows are often dry during summer drought. This hinders development and results in small plants with small capsules. The moss has been found on almost bare rocks, but further investigation revealed that the rocks had been submerged until mid summer. The moss may form clear stands where the soil is predominately damp and relatively infertile.

ROSACEAE

Potentilla canadensis (cinquefoil) -- found on dry sandy or gravelly soil. This species does best where competition is low on poor relatively dry soil. It can be used as an indicator of poor fertility. Some consider it also an indicator of acid conditions as it survives well in acid soil. Where this plant is found growing in abundance one should not expect good results of forest trees set out for reforestation. Conditioning of the soil will eliminate the plant through competition. The plant may serve some useful purpose as an anchor for soil that might otherwise be exposed to the elements and eroded away.

Rubus pubescens (trailing rubus) -- found on dry slopes and in clearings where the soil is barren and quite acid. Also present in old fields and open woods.

Spiraea latifolia (broad-leaved meadowsweet) -- found on moist, rocky or sandy soils in old fields and open woodlands, also bordering upland swamps. The presence of this shrub may indicate poor drainage.

RUBIACEAE

Mitchella repens (partridgeberry) -- found in shady places of woodlands where soil is moist and peaty. Requires moist acid soil. Will not survive in full sun.

UMBELLIFERAE

Daucus carota (Queen Anne's lace) -- a native of Asia, naturalized via Europe. It is considered a pernicious weed ("wild carrot") by farmers. The plant will grow in any dry place not under continuous cultivation.

APPENDIX H

BIRD CENSUS DATA FOR FOUR REGIONS IN NORTHEASTERN MASSACHUSETTS AND CAPE COD

NEWBURYPORT AREA

SPECIES	1972		1971		1970		1969		1968		1967		MEAN ($\bar{X}$)
	GROUP I	GROUP II	GROUP I	GROUP II	GROUP I	GROUP II	GROUP I	GROUP II	GROUP I	GROUP II	GROUP I	GROUP II	
Scarlet Tanager				11									2
Ring-neck Pheasant		13		8		5		13		7		12	10
Herring Gull	110		37		77		110		54		114		84
Rock Dove		7						7	23				6
Yellow-shaft Flicker		5		6		7		5		16		11	8
E. Phoebe		5						5		7		6	4
Tree Swallow		15				11		15		6		12	10
Bank Swallow		15				12		15					7
Barn Swallow		14		13				14	26			11	13
Blue Jay	36		20			18	36			17	46		29
Common Crow		18				18		18	20		33		18
Black-capped Chickadee	25			14			25		29			16	18
White-Brown Nuthatch		11						11		5		5	5
House Wren		17		6				17		18	18		13
Catbird	26			11		15	26		39		42		26
Robin	88		57		55		88		87		81		76
Wood Thrush		7				5		7				14	6
Veery		9		5				9		5		6	6
Starling	30		75		78		30		118		137		78
Red-eyed Vireo		5		12				5		13	23		10
Yellow Warbler		14				7		14		18	20		12
Yellowthroat	22			17		18	22			16	29		21
Gt. Crested Flycatcher										10		13	4
House Sparrow	42		45		22		42		54		61		44
Bobolink	20						20			6		6	9
E. Meadowlark		6		13				6		15		14	9
Red-winged Blackbird	82		69		29		82		93		58		69
Baltimore Oriole		11						11	26		22		12
Common Grackle	56		34		44		56		204		159		92
Brown-head Cowbird		6		8				6		14	24		10
American Goldfinch		8				5		8		7	20		8
Rufous-sided Towhee	35		24			16	35		48		36		32
Savannah Sparrow		7						7		6			3
Chipping Sparrow		11		10		10		11	20			19	14
Song Sparrow	31		31			12	37		36		39		31
Ring-billed Gull				6					28				6
Mourning Dove			26			7				6			6
E. Kingbird				6						8		11	4
Chimney Swift									27			16	7

MIDDLESEX - WORCESTER COUNTY REGION

SPECIES	1972		1971		1970		1969		1968		1967		1966		MEAN ($\bar{X}$)
	GROUP I	GROUP II	GROUP I	GROUP II	GROUP I	GROUP II	GROUP I	GROUP II	GROUP I	GROUP II	GROUP I	GROUP II	GROUP I	GROUP II	
Mourning Dove		10		8		6		8						5	5
Rock Dove		16						8		8					4
Chimney Swift		9		13		6		16	20			11	22		14
Yellow-shaft Flicker		10		7		7		8		9		6		8	8
E. Kingbird		6				8		7		11		8		9	7
E. Phoebe		6		7		4		8		6		6			5
Least Flycatcher		5						6							2
Tree Swallow		14		11		7		9		14		19		6	11
Barn Swallow		10		14		14		11		14		10	24		14
Blue Jay	36		26		20		38		40		32			16	30
Common Crow	23		18			12	25			16		15		9	17
Black-capped Chickadee		14	19			15		16		19		14			14
House Wren		8		11		7		10		8		7		7	8
Catbird		19		15		15	20			19		10		11	18
Brown Thrasher		6						6		5		6			3
Robin	83		70		78		77		82		62		84		76
Wood Thrush	25		28		17		24			12		8		6	17
Veery		7		6				6		6		6			4
Starling	102		69		74		113		158		87		193		114
Red-eyed Vireo	27		26		24		23			18		10		6	19
Black-and-white Warbler		8		7											2
Chestnut-sided Warbler		7		8		7		7						6	5
Ovenbird		16		14		10		12		10		13		7	12
Yellowthroat	28		22		20		22		20			19		15	21
House Sparrow	40		26		26		37		22		28		33		30
Red-winged Blackbird	44		35		32		38		34				21		29
Baltimore Oriole		13		9		7		14		11		10		6	10
Common Grackle	44		48		38		54		49		39		28		43
Brown-head Cowbird		9				7		8							3
Scarlet Tanager		9		8		5		9		6					5
American Goldfinch		5		7						7					3
Rufous-sided Towhee	39		30		38		41		35		25		24		33
Chipping Sparrow		14		14		10		15		16		8		11	12
Song Sparrow	33		27		27		32		30			14		18	26
Cedar Waxwing				8				5							2
E. Meadowlark				5		5		10		5				7	4

CONTINUED

CONTINUED

SPECIES	1972		1971		1970		1969		1968		1967		1966		MEAN ($\bar{X}$)
	GROUP I	GROUP II	GROUP I	GROUP II	GROUP I	GROUP II	GROUP I	GROUP II	GROUP I	GROUP II	GROUP I	GROUP II	GROUP I	GROUP II	
Rose-breasted Grosbeak				5											1
White-throat Sparrow				4						6					1
Bank Swallow						8									1
Ring-neck Pheasant						5						7			2
Yellow Warbler								6							1
Field Sparrow										6					1

*Group I >20 individuals per transect = abundant

Group II >5 but <20 per transect = common to fairly common

EAST DENNIS AREA (CAPE COD)

SPECIES	1972		1971		1970		1969		1968		1967		MEAN ($\bar{X}$)
	GROUP I	GROUP II	GROUP I	GROUP II	GROUP I	GROUP II	GROUP I	GROUP II	GROUP I	GROUP II	GROUP I	GROUP II	
Bobwhite	36		47		57		30		23		42		39
Herring Gull	21			8		12	34		226			8	52
Mourning Dove		13	28		20		21		110		21		36
Chimney Swift		11		9		16		18		13		7	12
E. Wood Pewee		6		6		9							4
Blue Jay	32		36		35		35			12	54		34
Common Crow		11	21			15	24			9	21		17
Black-capped Chickadee		18	36		25		29			11	24		24
Catbird		15	32		28		39			16	21		25
Robin	42		77		55		75		40		32		54
Starling	21		44		121		60		22			9	46
Red-eyed Vireo		7		8									2
Yellowthroat		15		15		16	50		21			19	23
House Sparrow	31		68		31					13	24		28
Red-winged Blackbirds	20		30		32		37		40		31		32
Baltimore Orioles		14		14	20		43				24		19
Common Grackles	32		60		29		62		75		43		50
Brown-hd. Cowbird		6											1
Am. Goldfinch		6				12		6		6		14	7
Rufous-sided Towhee	31		34		43		42		34		55		40
Chipping Sparrow		7		13		19	30			9		10	15
Song Sparrow		11		19	24		40			15	22		22
Yellow-shaft Flicker				13				5		8		18	7
Barn Swallow				7		5							2
Wood Thrush				6		8		9					4
Ovenbird				9		10				5		5	5
Yellow Warbler				5				15		6		8	6
Ring-necked Pheasant								5					1

WELLFLEET AREA (CAPE COD)

SPECIES	1971 GROUP I	1971 GROUP II	1970 GROUP I	1970 GROUP II	1966 GROUP I	1966 GROUP II	MEAN ($\bar{X}$)
Bobwhite	48		44		62		51
Ring-neck Pheasant		6					2
Herring Gull	46		24		55		42
Mourning Dove	51		43			10	35
Yellow-shaft Flicker		11		7			6
E. Kingbird		11		8		7	9
E. Wood Pewee		10				8	6
Blue Jay	50		46		61		52
Common Crow	36		28		40		35
Blk-capped Chickadee	64		51		43		53
Catbird	31		34		53		39
Robin	43		102		70		72
Starling	34		75		153		87
Red-eyed Vireo		9				6	5
Black-and-white Warbler		7		7			5
Yellow Warbler		16				15	10
Prairie Warbler		9				18	9
Yellowthroat	45		73		49		56
House Sparrow	36		53		71		53
Red-winged Blackbird	50		79		81		70
Baltimore Oriole	28		21		29		26
Common Grackle	107		92		198		132
Brown-hd. Cowbird	22					7	10

CONTINUED

CONTINUED

SPECIES	1971 GROUP I	1971 GROUP II	1970 GROUP I	1970 GROUP II	1966 GROUP I	1966 GROUP II	MEAN ($\bar{X}$)
American Goldfinch		12					4
Rufous-sided Towhee	53		94		109		85
Chipping Sparrow	34			19	39		31
Song Sparrow	31		29		28		29
Mockingbird		12	22				11
Pine Warbler		12		17		18	16
Gt. Black-back Gull			26				9
Chimney Swift				12			4
Gt. Crest Flycatcher				10		8	6
Tree Swallow				6		18	8
Brown Thrasher						8	3
Cedar Waxwing						9	3
Field Sparrow						6	2
Common Tern						6	2

APPENDIX I

HABITAT REQUIREMENTS OF ABUNDANT BIRD SPECIES ENCOUNTERED IN EASTERN MASSACHUSETTS

APODIDAE

Chimney Swift -- This bird immigrates from late April to late May. It nests in June near the tops of chimneys, occasionally in unoccupied farm buildings or inside unused wells, but rarely in hollow tree trunks. Emmingration to the Caribbean and South America occurs from late July to early September. It feeds exclusively on flying insects.

COLUMBIDAE

Mourning dove -- This bird is a common summer resident and is found throughout suburbs and farmland in most areas of the state. Spring arrival of migrants takes place from late March to early April. Nesting is often begun by the third week of April and continues through the first week of July. Doves nest primarily in trees. They feed on grain seeds and fruit. During August, Mourning doves begin their southward movement and are frequently seen on outlying beaches and dunes. By mid October, virtually all have left the area.

CORVIDAE

Crow -- The crow is a permanent resident, at home in all habitats found in eastern Massachusetts. It nests in trees, 10 to 70 feet above ground, preferably in white pine, from April to mid June. Resident populations are temporarily augmented by migrants moving south from October to December and north from late February through March. Crows consume quantities of insects, especially grasshoppers when abundant. In farming regions 38 per cent of the diet may be corn. The crow also eats carrion, weed seeds, eggs and young of other birds, small rodents and wild fruits.

Blue Jay -- A conspicuous permanent resident, found in deciduous, coniferous and mixed coniferous - deciduous woods. From September to October and again from April to May migratory waves temporarily augment resident populations. Breeding occurs from May through June. Nests are constructed in tree crotches about 10 to 30 feet above ground. The bird eats insects of various kinds and ocassionally attacks nestlings of other species. Acorns and beech nuts are a dietary staple.

FRINGILLIDAE

Song Sparrow -- This widely distributed sparrow can be found throughout the eastern Massachusetts area except in dense forests or areas devoid of vegetation. The bird nests in low bushes or on the ground in grass thickets in brushy fields, along fence rows and the borders of marshes and swamps. A small permanent population overwinters in the southeastern part of the state. Large numbers immigrate in March to mid May. Breeding takes place between early May and late July. The bulk of the population emmigrates between September and late October. Two-thirds of the diet is plant material, largely seeds of weeds and grasses. Animal food consists of beetle larvae and other insects.

Rufous-sided Towhee -- This species occurs in hardwood and oak-pine forests inhabiting cut over land where sprouts and young saplings abound, or, in scrubby lands, of brush and briar patches. The nest is built on the ground or very near to it in low bushes or brush piles. Its food is chiefly seeds, wild fruits, insects, and worms, which are obtained from leaf litter. The towhee emmigrates to the area in early April to mid May. Breeding takes place from mid May to mid June. The bird emmigrates from August through October.

Chipping sparrow -- This sparrow immigrates to the state from late April to late May. Nesting occurs from mid May to late June in trees or bushes of hardwood or mixed lowland forests about 3 to 25 feet above ground. Nesting in ornamental shrubs and trees and in windbreaks of cultivated areas is common. Emmigration takes place from late July to early September. Food consists mostly of small insects, weed and grass seeds.

ICTERIDAE

Red-winged blackbird -- This bird is found wherever there is a body of water, either fresh or salt. It nests from late May to late June usually in marshes and swamps in low bushes and reeds, less than 15 feet from ground level. Immigration occurs from late February through April, and emmigration in August to early November. During the breeding season food consists mostly of insects. In the fall the diet is largely weed and marsh plant seeds. While these birds consume some grain they are not considered a pest in this area.

Baltimore Oriole -- This is a common migrant and breeding bird throughout the region. It arrives during early to mid May and nesting takes place from the end of May through the first week of July. Most fall migrants depart during the period from mid August to late September. It nests primarily on farm lands or along highways, in orchards, shade trees and often in elms, rarely in edge of woods. Its principal food consists of insects but during certain times of year wild and cultivated fruits are consumed.

Common grackle -- This blackbird immigrates from late February to April and breeds in colonies during May and June. The birds nest in coniferous trees and shrubs from 5 to 80 feet above ground in coniferous and mixed open woodland. Planted tree groves and parks are often utilized. Emmigration takes place from August through October. Food is listed as 30 per cent animal and 70 per cent vegetable. The diet consists of worms, crustaceans, carrion, birds eggs and young, snakes, clams, frogs and insects. In Autumn, grain, seeds from other cultivated and wild grass crops are consumed as well as nuts and wild fruits.

MIMIDAE

Catbird -- This bird immigrates during April and May. Catbirds inhabit thickets or brush, damp meadows and marshes. The nest is built in shrubby growth rarely more than 10 feet above ground. Viburnum or vaccinim bushes are typical nesting sites. Emmigration southward takes place from mid August to late October. A few birds may overwinter especially in coastal areas. The diet consists mainly of insects as well as wild and cultivated fruit.

PARIDAE

Black-Capped Chickadee -- This permanent resident may be found in deciduous, and mixed coniferous - deciduous woodlands. It avoids very dense forests, preferring clearings and border areas and often inhabits gardens, orchards and backyards. During winter, numbers of chickadees move closer to human habitation to take advantage of feeding stations. Breeding occurs in May through June. The nest is excavated in the soft wood of a partly decayed dead tree limb or trunk. More than half the diet is composed of insects. Only about a

third of the diet is plant material.

PARULIDAE

Yellowthroat -- This bird definitely favors moist locations with thickets and low bushes (e. g. alder, willow, steeplebush). Nests are built on or near the ground, usually in a thicket or grass clump in bogs, wet meadows or hedgerows along stream banks. This warbler immigrates during May and breeds until late June. Southward emmigration takes place from late August to mid October. Its diet is composed largely of insects.

PHASIANIDAE

Bobwhite (quail) -- This is a bird of brushy open ground. In the southeastern portion of the state it is a common permanent resident associated with dense briar thickets and ground hugging bushes interspersed with cultivated fields and fallow fields. Nesting occurs in May to September in a slight cavity in the ground. Food consists of weed seeds, corn and other grains, ragweed lespedeza, acorns and insects.

PLOCEIDAE

House Sparrow -- This small finch was introduced from Europe in the 1850's and has since become a permanent resident. It nests in eaves and similar structures of buildings in cities and towns. Breeding takes place from April to August. The bird is able to subsist on a wide variety of foods and is extremely tolerant of urban conditions.

STURNIDAE

Starling -- This species is now the most common bird in eastern Massachusetts. It was introduced from Europe in the 1890's and has become a permanent resident. It nests in tree hollows or building eaves and crevices especially near human habitation. The resident population is augmented by migrants from the north moving into and through the state from mid September to mid December. More than half of the diet consists of insects. Plant food includes grain, wild and cultivated fruits.

TURDIDAE

Robin -- The natural habitat of this familiar thrush is sparsely wooded areas, but an affinity for man has led to the adoption of backyards, gardens and orchards as typical nesting sites. Breeding takes place from late April to late July. The nest is built in a tree crotch or among the higher branches from 5 to 70 feet above ground. Robins eat wild and cultivated fruit as well as insects and worms.

APPENDIX J

HABITAT REQUIREMENTS OF PRINCIPAL MAMMALS OF NORTHEASTERN MASSACHUSETTS AND CAPE COD

CERVIDAE

White-tailed Deer (*Odocoileus virginianus*). Mixed or deciduous woodland with an understory, forest edges and farmland. Usually avoids dense stands of mature conifers (except in winter) and very extensive open areas. Groups spend colder months in lower elevations or on warmer slopes (thickets, bottom lands). In deep snow they may utilize tamarack and spruce swamps. The deer is a selective browser yet with a highly variable diet. Among preferred browse is yew, *Taxus spp.*; white cedar, *Chamaecyparis thyoids;* hemlock, *Tsuga canadensis;* mountain ash, *Sorbus americana;* red maple, *Acer rubrum;* dogwood, *Cornus alteunifolia;* wintergreen, *Gaultheria procumbens;* cranberry, *Vaccinium macrocarpum*. The list of deer food includes about one hundred plant species including succulent and aquatic plants, legumes, mushroom, nuts and lichens. In winter deer have been known to consume large quantities of food having little nutritive value rather than move to nearby areas having more adequate food.

LEPORIDAE

Eastern cottontail (*Sylvilagus floridanus*). Diverse and variable, always near cover suitable for concealment, never in dense forests nor short grass unless as a transient. Suitable habitats include: sparse woodland with numerous thickets, brush piles, and fallen trees; uncultivated dry swampland abounding in tall grasses, sedges, and brushy shrubs; grass and weed patches and thickets on farms, particularly along fences and stone walls, or in corn fields of advanced growth; hay fields or fall alfalfa, clover or timothy; cut over lands and slashings, or burns, especially where new vegetation has started; orchards and gardens, particularly if near patches or borders of weeds, tall grass or brush even in towns and villages. Cottontails will eat almost any kind of green vegetation including buds, sprouts, tender shoots of many woody plants, stems of a few shrubs, particularly of the genus *Rubus* (blackberries and raspberries). It is especially fond of legumes and certain grasses; dandelion, plaintain and lettuce. It will not eat hard ripe grain, dry straw, tubers and bulbous roots. During winter cottontails subsist on the tender parts, inner and outer bark of trees and shrubs (71 species). Hunting, predation, disease and starvation are the primary motality agents. Rabbit populations fluctuate widely, especially with lack of natural predator control. Ten or eleven year cycles have been observed.

New England Cottontail (*Sylvilagus transitionalis*). Open forest with brushy understory, also brushy areas, mainly in hills and mountains. Not as common as eastern cottontail. Food habits somewhat similar.

Varying hare (*Lepus americanus*). Mixed woodlands, conifers, wooded swamps, and brushy areas; old burns and cut over lands covered with fallen logs and limbs, growths of young aspens, raspberry bushes, alders, willows and other vegetation; heavy mature hemlock forest with ferns and fallen logs. Rarely found in pure hardwood forest -- must be interspersed with conifers and brush. Rarely found in old stands of pine with bare forest floor. Food consists of many herbaceous plant species particularly clover (*Lespedeza, Melilotus* and *Trifolium spp.*) dandelion, strawberry, ferns; the succulent parts of aspen (*Populus spp.*) willow (*Salix spp.*), alder (*Alnus spp.*) and paper birch (*Betula papyrifera*). In winter with food scarce the hare will consume pine (*Pinus spp.*) and cedar (*Chamaecyparis, Juniperus spp.*). Population fluctuations are more stable than in the cottontail but still fluctuate widely. Nine to ten year cycles have been observed.

MUSTELIDAE

Striped Skunk (*Mephitis mephitis*). Brushland and sparce woods; grassy and weedy fields and pastures, especially along brushy borders; under woodpiles, rockpiles and buildings; most common along brushy borders of lakes and streams and in thickets in gulches and at the base of cliffs. Makes a den in a dry place. Forty to 50 per cent of the diet is insects. About 10 to 20 per cent is mice mostly *Microtus* and *Peromyscus* and infrequently *Zapus*. Shrews, moles and squirrels are also taken. Thirty per cent of its diet is vegetable matter, especially during the summer, and includes primarily (*Cornus, Morus,* and *Prunus*). In winter grains, grasses, leaves and buds are eaten.

Short-tailed weasel (*Mustela erminea*). Brushlands and open wood lands; field borders around stone walls, woodpiles, barns and old buildings. Never abundant but populations are relatively stable. Nests underground. Half of the food consumed consists of mice (*Microtus, Clethrionomus* and *Peromyseus*). Chipmunks, shrews and, rarely, young rabbits are eaten. Five per cent of the diet consists of wild birds.

Long-tailed weasel (*Mustela frenata*). Open woodland, brushland, brushy field borders, especially near creeks, lakes and other bodies of water. Nests underground. More than 50 per cent of the diet consists of *Microtus* and *Peromyscus;* 12 per cent includes young rabbits. Also preys on chipmunks, shrews and occasionally moles.

Mink (*Mustela vison*). Found mainly along water courses; banks of lakes, marshes, rivers and other water ways, particularly if forested, log strewn or bushy. Mink may move into the woods in the winter when water bodies freeze over. The den is never far from water often in an abandoned muskrat home. The mink's diet varies seasonally; in winter most of the diet is mammalian (especially muskrats).

River Otter (*Luter canadensis).* Chiefly found along major waterways. Found away from waterways only as a transient. Eats mainly non-game aquatic vertebrates and invertebrates, also muskrats, rabbits and some water fowl.

Fisher (*Martes pennanti*). Rarely occuring in Massachusetts. It is limited to the more extensive forest tracts. Prefers cut over areas grown to mixed deciduous - coniferous species. While this animal is omnivorous, it preys especially on porcupine and snowshoe hare.

PROCYONIDAE

Racoon (*Procyon lotor*). Forest and wooded areas particularly old hardwood timber with hollow trees, and especially near water. The racoon is nearly omnivorous, eating more plant than animal food although it belongs to the order Carnivora. Diet varies with season and availability of food. Foods eaten include: fruits of many plants (e.g. the following genera: *Cornus, Crataegus, Amielanchier, Celtis, Gaylussacia, Malus, Morus, Prunus, Rubus, Vaccinium, Viburnum;* plus currant, wild grape, tomato, cantaloupe, watermelon and *Phytolacca americana),* nuts such as acorns, hickory nuts, hazelnuts, and beechnuts; field corn, sweet corn, oats, seeds of ragweed and smartweed, and tender shoots and bulbs of many other plants. Animal food typically makes up 30 to 40 per cent of the diet (rarely up to 70 per cent seasonally). Animals eaten include crustaceans, molluscs, annelids, insects, shallow water fish species such as the brown bullhead, amphibians, eggs and immature birds and

turtles, small mammals such as mice, shrews, and occasionally carrion. Corn, berries, acorns, crayfish and insects rank high in importance.

DIDELPHIDAE

Opossum (*Didelphis marsupialis*). Deciduous swamps, woodlands, wastelands, and hedgerows having dense cover, and particularly along streams or near lakes. Occasionally comes near rural dwellings. May be common on farmland. Mainly nocturnal. Diet is unrestricted, will feed on carrion, spoiled fruits, fresh fruits, nuts, occasionally birds. Insects form 90% of its diet.

FELIDAE

Bobcat (*Lynx rufus*). Wilderness areas of brushy and wooded country, favors swamps and rocky terrain. Half of the diet is made up of cottontails and varying hares. Diet also includes many other mammal species and birds, including grouse.

CANIDAE

New England Coyote (*Canis latrans*). The coyote prefers irregular terrain, with open areas, brush and woodlands; is at home in fairly wooded areas. Feeds primarily on rabbits, rodents and birds. Carrion will be consumed if available. Coyotes will feed on plant material in times of food scarcity. They occasionally feed on poultry, livestock and big game.

Gray Fox (*Urocyon cinereoargenteus*). Hardwood or mixed hardwood-coniferous forests, brushlands, and dense weed patches, particularly in rough hilly terrain; sometimes found in heavy woods on bottomlands; favors vicinity of streams and lakes. Not a common animal; greatly outnumbered by the red fox. Chiefly nocturnal. Diet includes fresh fruits, corn acorns, but favors prey such as rabbits, rodents, insects and rarely birds.

Red Fox (*Vulpes fulva*). Hilly farmland; dry upland with open areas and patches of cover, such as brushland, cropland and pasture. Also in lowlands, swamps, marsh edges, stream and lake side bottom lands. Occasionally tranverses towns and suburban areas. Avoids dense forests. Between 50 and 90 per cent of the food consumed is mammalian, chiefly the

cottontail, especially in winter. Red fox also prey on the varying hare, where plentiful, and various species of mice, especially meadow voles. It will prey on ground-feeding birds when mammals are scarce. Plant foods eaten include berries (Genera: *Amelanchier, Malus, Prunus, Rubus, Morus, Viburnum*), grapes, acorns, hickory nuts, and corn. Population fluctuations occur following changes in rabbit and rodent populations.

SCIURIDAE

Eastern Gray Squirrel (*Sciurus carolinonsis*). Hardwood forests or occasionally mixed coniferous - hardwood forests, particularly woodland stands with nut bearing trees preferably with bushy undergrowth. Also in river bottom land, near water courses or lakes, or bluffs or slopes along such waters; sometimes in small wood lots or along wooded fence rows; frequently seen in wooded parks and residential sections of towns and villages. Food consists of many varieties of nuts, especially acorns; seeds; fruits, particularly seedy fruits or trees such as maple (*Acer*), elm (*Ulmus*), Hornbeam (*Carpinus caroliniana*), hackberry (*Celtis occidentalis), Viburnum spp.*, cherry (*Prunus spp.)*, mulberry (*Morus rubra);* buds, particularly of maple and elm; occasionally, corn and other grains (germinal parts only); sometimes, underground fleshy parts of plants. They gray squirrel eats a small amount of animal food such as insects, including weevils, caterpillars, and insect galls. Gray squirrels have been known to rob bird's nests for eggs and young.

Red Dquirrel (*Tamiassciurus hudsonicus*): Chiefly in coniferous forests or mixed forest of coniferous and deciduous trees; frequently in pure stands of deciduous trees particularly if in wet terrain. Builds its nest in tree branches or tree hollows if available. The nest is usually 30 to 60 feet above ground. The chief food is seeds of coniferous trees. The inner bark and buds, blossoms, and tender leaves of maples, aspens, willows, and birches are also consumed. Also, in the diet are wild and cultivated strawberries, wintergreen (*Gautheria*) berries, blueberries, wild red cherries, hazelnuts, acorns, beechnuts, and several varieties of mushrooms. Hard food items are cached in stumps, logs and hollow trees. Like the chipmunk, this squirrel will occasionally feed on insects and snails. The red squirrel is not a particularly important item in the diet of any predator.

Eastern Chipmunk (*Tamias striatus*). Open forests, particularly where hardwoods occur; brushland and cut over land; rocky wooded bluffs, particularly with ledgy areas; wooded or brushy fence lines, around stone walls, brush piles, rubbish heaps, old buildings and log cabins. Occasionally the animal is found in gardens, village yards, and parks where ground shelter is available. Like most squirrels this one is active by day. Burrows are well hidden and protected. Tunnels go straight down and then turn laterally. The principal food consists of nuts; fruits, seeds of many woody plants (maple, oak, hazel, basswood, hickory, beech, elm, box elder, wild and cultivated cherries, blackhaw, nannyberry and arrow wood *Viburnum spp.*, Virginia creeper); some cultivated grains such as corn, wheat, and oats; seeds of weeds and grasses, wild fruits and berries (raspberry, strawberry, blueberry, wintergreen (*Gaultheria procumbens*), gooseberry barberry); legumes; and occasionally mushrooms and other fungi. A small amount of the diet is animal matter, chiefly insects and snails. Food is stored in underground dens. The population fluctuates markedly, peak numbers occurring at intervals of several years.

Woodchuck (*Marmota monax*). Dry soil on open woodlands, forest borders, thickets, rocky slopes, and in and about fields and clearings. It favors edges of brushy woodland, particularly near open fields along streams or lake banks, poorly cleared fence lines, railroads and roads; also clearings, meadows, pastures, and grain fields, especially where near the crest or brow of a hill; attracted to old stumps, rocky outcrops, and piles; not infrequently near a barn or outbuilding, an unoccupied house or shack, or a large pile. Its food consists of green vegetation, particularly legumes. It readily eats growing grain crops and many species of grasses, as well as raspberries, blackberries, strawberries, cherries and apples. It will feed on beet and turnip tops, cabbage, kale and cantaloupe. Occasionally this animal takes animal food such as grasshoppers, beetles and snails.

Southern and Northern Flying squirrels (*Glaucomys volans* and *G. sabrinus*). Southern: forests and groves of deciduous trees, including old orchards; also woodlands of mixed hardwoods and conifers, particularly where hardwoods predominate. Northern: heavily wooded areas of mixed conifer and deciduous trees of mature growth, preferably moist forest with many fallen large decaying and mossy logs. Sometimes it is found in pure stands of *Thuja occidentalis* and *Picea spp.* or *Abies spp.* Especially

favors hemlock-maple or hemlock-gray birch stands. Rarely in pure hardwood forest. Both species are strictly nocturnal. Nests may be found from a few feet from the ground to 35 feet, often in a loft of a building. Food consists of nuts and seeds of wide variety. The northern species includes spruce and fir seeds in its diet which the southern species does not. While the southern squirrel eats some insects, such as moths and beetles, the northern squirrel is more omnivorous, utilizing various sources of meat (fresh, dried or putrid). Flying squirrels usually remain active all winter. The northern squirrel, which spends more time on the ground, serves as a food source for carnivorous mammals when mice and other small mammals are buried under deep snow.

CASTORIDAE

Beaver (*Castor canadensis*). Various waterways which are impounded to form ponds. Beavers especially single out a water course near a stand of aspen (*Populus tremuloides*). The natural food of the beaver actually includes a wide range of plants. In summer it eats sedges, rushes, water grasses, lily pads and roots, roots and tubers of a variety of water plants, and some bark, leaves and twigs of woody plants on the shore. In winter the animal subsists on green branches which have been stored under water. Hardwoods, frequently ingested include species of *Populus, Alnus, Salix, Fraxinus, Acer negundo, A. spicatum,* and *Betula papyrifera*. An acre of *Populus spp.* can feed a colony of 6 or 7 beavers for a year or more.

ERETHIZONTIDAE

Porcupine (*Erethizon dorsatum*). Woodlands, those containing conifers or poplars, being preferred. This species feeds upon the inner bark, branches and leaves of trees. Coniferous species utilized include hemlock, spruce, fir, white and red pine; among the deciduous species are willow, beech, maples, quaking and bigtooth aspen, yellow, black and paper birch. In summer will consume roots, nuts and fruits. It is mainly nocturnal. They den in hollow trees, logs or among rocky outcrops.

CRICETIDAE

White-footed mouse (*Peromyscus leucopus*). Mixed hardwood - coniferous or hardwood forest, often densely brushy areas such as

fence lines, occasionally more open grassy areas bordering woodland. Seldom more than fifty feet from trees. This mouse especially prefers oak - hickory. Sometimes it is excessively common in rocky ravines with walls that contain many cavities. This is the most abundant truly forest species. Normal populations are about 3 to 4 adults per acre. Principal food consists of seeds of grasses, weeds, clover, small fruits and grain; nuts, particularly acorns and hazelnuts. This mouse does consume green herbage and insects. Nests in trees about six to eight feet from the ground. Stumps, logs and rocky outcrops containing cavities are also favorite nesting sites. Hard food is stored in small caches in these cavities. This mouse is important in the diet of many fur bearing species. Owls are also important predators.

Red-backed Vole (*Clethrionomys gapperi*). Woodland and forest (coniferous, deciduous and mixed). This mouse inhabits moist woodlands strewn with mossy logs or matted tall grass. Occasionally it is found in dry *Betula papyrifera* stands or in less watery places and among *Thuja occidentalis* in tamarack (*Larix*) swamps. This species is numerous but not as much so as *Peromyscus*. Unlike *Peromyscus* this mouse makes its own runways, often obscured by sphagnum and other mosses. Nests are made under rotted logs or stumps. The food is mostly vegetable matter. The species consumes hazelnuts; beechnuts; hemlock, spruce and maple seeds; fruit or seeds of *Prunus, Amelanchier, Rubus, Sorbus, Vaccinium Mitchella repens, Ilex verticillata* and *Clintonia,* bark of many woody plants, and occasionally fungi. The species consumes fewer insects than *Peromyscus* (about 10 per cent of the diet).

Meadow Vole (*Microtus pennsylvanicus*). Chiefly lowland fields and meadows, grassy marshes, along rivers and lakes, and similar grassy areas. Sometimes found in flooded marshes or on high grasslands near water; orchards and open woodland if ground cover is of grassy or weedy growth; sometimes in grain, hay and agricultural fields; and occasionally in sphagnum bogs. This mouse is the most abundant mammal in Massachusetts. Population peaks occur every one to four years. At that time favorable habitats may harbor as many as two hundred mice per acre. The vole subsists chiefly on grasses, legumes, sedges, and other herbage, also grains and seeds of many varieties. During the growing season the diet consists mainly of greens and succulent vegetation. In harvest season, corn and other grains are eaten as they stand in the field (both foliage and seeds). In winter the diet is supplemented with the bark

and roots of woody plants. This vole will eat certain bulbs and tuberous roots as well as green fruit. In areas of *Vaccinium macrocarpon* (cranberry) the mouse eats the seeds discarding the berries. Less than five per cent of the diet is animal material. In abundance this mouse is a major pest of grain crops. Ten mice per acre on a 100 acre meadow could take 11 tons of grass or 5.5 tons of hay in a year. However, the animal also destroys weeds (especially weed grasses) and is very important in the diet of many fur-bearing mammals and raptorial birds.

Pine Vole [*Pitymus (=Microtus) pineforum*]. Despite the common name this mouse is seldon found in pure pine stands. Its main requisite is thick leaf mold or loose soil in forests (deciduous or mixed; preferably in oak, red and/or white) or grazed woodlots, with friable top soil. It is also found in sandy fields and brush land. It is often located on rocky hills of some elevation and has been recorded in sphagnum swamps and mucky areas. This rodent feeds mainly on roots, tubers, bulbs and bark of woody plants as well as some green vegetation, fruits and berries. Like other voles this one constructs extensive burrows and tunnels, but in this case they are deeper, often two or three inches below the soil surface.

Muskrat (*Ondatra zibethicus*). Marshes, lakes, slow running streams, and other sources of fresh water. This rodent builds a den or burrow in the banks or a "house" as does the beaver. The chief foods are aquatic plants, particularly cattail (*Typha latifolia*), arrow head (*Sagittaria graminea*), spike rush (*Fleucharis aricularis*), water bullrush (*Scirpus subterminalis*, pickerel weed (*Pontedaria cordata*) and large-leaved pond weed (*Potamogeton amplifolius*).

ZAPODIDAE

Meadow Jumping Mouse (*Zapus hudsonius*. Meadows, shrubby fields, brushland and thickets along the edge of woods; usually in a moist grassy situation, and preferably near a stream or lake. This species is quite local in distribution, seldon found in as much abundance as other mice species. Although not subject to natural population cycles, numbers do vary from year to year. In particularly favorable locations, populations may range from a high of ten per acre to a low of less than one. This rodent

hibernates early in winter. It feeds almost exclusively on seeds, grass, grains and weeds. Also eaten are flesh fruits of various plants and insects. Food is rarely stored. The animal drinks a considerable amount of water.

Woodland Jumping Mouse (*Napaeozapus insighis*). Along creeks or in small low damp openings, usually in grassy brushland or second growth, predominantly in *Alnus* or *Betula papyrifera*, sometimes in mixed timber of *Thuja occidentalis, Acer, Populus,* or *B. papyrifera*. Never found in open meadows, fields, or marshes far from brushland or woods, as is *Z. hudsonius*. Food consists of seeds, fleshy fruit, various plant parts (especially fleshy rootlets exposed by water action along brook banks) and insects. Seeds of *Mitella diphylla* and the green fruit of *Podophyllum peltatum* are favorites. The mouse has a special fondness for *Alnus* cones. Blueberries and raspberries are consumed, as are fragments of *Asplenium* fronds.

MURIDAE

Norway Rat (*Rattus norvegicus*). A domestic pest, this rat ranges into the country side in summer. Though able to swim it does not favor watery areas. Its high reproductive potential is typical of rodents. Although this rat burrows in the ground, it nests in trash piles or dumps. The diet depends on man; it relies on human garbage and food refuse as well as food stores when accessible. Rats are vectors of numerous human and animal diseases. This animal is more likely a factor in solid waste disposal than in liquid waste disposal.

House mouse (*Mus musculus*). Like the rat it is a domestic animal, although it can be found in fields and meadows during the warm months. The house mouse is about twice as abundant as the rat. This specieis is quite omnivorous. It is not as serious a pest as the rat.

TALPIDAE

Eastern mole (*Scalopus aquaticus*). This mole is found in well drained light sandy soils and light loams in grassy meadows, pastures, cultivated fields, gardens, lawns and open woodlands. It does

not occur in gravelly or rocky soils or wet and swampy areas. This mole is not particularly common in Massachusetts. Eighty per cent of the food is animal matter, mostly earthworms and insect larvae.

Hairytailed mole (*Parascalops breweri*). Usually in well drained soil, where there is a more or less woody growth, occurring less in fields and damp gullies. Food includes earthworms, various insects, and other small invertebrates. Not numerous, one or two moles per acre is considered a high density.

Star-nosed mole (*Condylura cristata*). This mole occurs in moist, wet or even watery ground, not far from water, swamps or marshes. It is occasionally found where the soil is moist and loose. It prefers a soil of mulch, humas, or light sandy loam and is probably found as frequently in wooded and brushland areas as in open places. The nest or burrow is situated above high water level, usually in a small hillock or knoll, three to five inches beneath the ground surface. The natural food of this mole consists chiefly of aquatic worms, insects and other invertebrates. Less than 25 per cent of its food is terrestrial in origin.

SORICIDAE

Masked shrew (*Sorex cinereus*). This shrew prefers a moist or damp, but not necessarily watery, habitat. Generally occurring in either coniferous or deciduous forest, it is sometimes found in marshes, grassy bogs, spruce-cedar swamps, alder (*Alnus*) thickets along brooks, mossy banks, as well as spruce, tamarack or leatherleaf bogs. Rarely is this shrew found in dry woods or even fields. It occupies the runways and burrows of other small mammals. Insects and other invertebrates make up most of the diet, vertebrates about 7 per cent.

Short-tailed shrew (*Blarina brevicauda*). This large shrew occurs in almost any type of woodland where there is sufficient vegetative litter to provide cover. In times of low population densities it occurs more plentifully in damp brushy woodlands, bushy bogs and marshes, and weedy and bushy borders of fields and along brooks, lakes and sloughs. During normal or heavy populations it may be found additionally in tamarack and spruce swamps, sphagnum bogs, and infrequently in cultivated

fields. It is slow in reinhabiting forest burns. The shrew population is subject to fluctuations in density with peaks occurring at approximately four year intervals. This is a numerous animal, although it does not compare with population densities of some mouse species. At normal densities there are approximately 4 animals per acre. The short-tail shrew feeds largely on insects and other invertebrates as well as young mice (nearly 80 per cent of diet). Most of the vegetable matter consumed is in the form of nuts.

Little Brown Myotis *(Myotis lucifugus)*. This bat is found in caves, caverns, abandoned mine diggings, and deep clefts in rocks; and in buildings. At night bats fly about woodlands, especially along water courses. In Massachusetts, the little brown myotis far outnumbers all other bat species combined. The bat eats only nocturnally flying insects. Its value in insect control is at least partially offset by the fact that it is a carrier of rabies. There are no important natural enemies.

Myotis (*Myotis keenii*). Habits are the same as *M. lucifugus*. This bat is from one third to one tenth as common as the little brown bat.

Eastern Pipistrel (*Pipistrellus subflavus*). This bat is found in crevices in cliffs or in buildings.

Big Brown Bat (*Lasionycteris noctivagans*). This species is found in forested regions.

Hoary bat (*Lasiurus cinereus*). This bat inhabits forested regions. Rests in trees by day.

Red Bat (*Lasiurus borealis*). Bat common in deciduous forest, open woodlands, and orchards.

APPENDIX K.

SUITABILITY OF SOILS FOR VARIOUS TYPES OF PLANT ASSOCIATIONS[1]

SERIES	TEXTURE CLASS	SLOPE[3]	GRAIN AND SEED CROP[2]	GRASS AND LEGUME[2]	HARDWOOD FOREST[2]	CONIFEROUS FOREST[2]
Acton	Fine sandy loam	A,B	2	1	2	2
	Very stony fine sandy loam	B,C	4	3	2	2
Agawam	Fine sandy loam	A	1	1	1	3
		B,C	2	1	1	3
		D	3	2	1	3
Au Gres	Loamy sand	A,B	3	2	2	2
Buxton	Silt loam	A,B	2	1	1	3
Canton	Fine Sandy loam	A,B	2	1	2	2
	Very stony fine sandy loam	B,C	4	3	2	2
Carver	Loamy coarse sand	A,B,C	3	3	3	2
		D	4	3	3	2
Charlton	Fine Sandy loam	A,B,C	2	1	1	3
Deerfield	Loamy sand	A,B	2	2	2	2
Dukes	Coarse sand	A,B,C	3	3	3	2
Elmwood	Very fine sandy loam	A,B	2	1	1	3
Enfield	Very fine sandy loam	A	1	1	1	3
		B,C	2	1	1	3
Essex	Fine sandy laom	A,B,C	2	1	1	3
	Very stony fine sandy loam	A,B, C,D,	4	3	1	2
	Extremely stony fine sandy loam	B,C,D	4	4	1	2
Hadley	Very fine sandy loam	A	1	1	1	3
		B	2	1	1	3

CONTINUED

SERIES	TEXTURE CLASS	SLOPE	GRAIN AND SEED CROP	GRASS AND LEGUME	HARDWOOD FOREST	CONIFEROUS FOREST
Hinckley	Loamy sand	A,B,	1,2	1	1	3
	Very stony loamy sand		4	3	1	3
Hollis	Very rocky fine sandy loam	C,D	4	3	2	2
	Extremely rocky fine sandy loam	D	4	4	3	2
Limerick	Silt loam		3	2	1	2
Merrimac	Fine sandy loam	A	1	1	1	3
		B,C	2	1	1	3
		D	3	2	1	3
	Sandy loam	A,B,C	2	1	2	3
		D	4	3	2	3
Muck	Shallow		4	3	4	1
	Deep		4	3	3	1
Narragansett	Very stony very fine sandy loam		4	3	2	2
Ninigret	Fine sandy loam-Silty subsoil variant	A,B	2	1	1	3
Paxton	Fine sandy loam	A,B,C	2	1	1	3
		D	3	2	1	3
	Very stony and extremely stony fine sandy loam	B,C,D	4	3	1	3
Ridgebury	Fine sandy loam	A,B,	3	2	1	2
	Very and extremely stony fine sandy loam	A,B	4	4	1	2
Saco	Silt loam		4	3	1	1
Saugatuck	Loamy sand		4	3	1	1

CONTINUED

SERIES	TEXTURE CLASS	SLOPE	GRAIN AND SEED CROP	GRASS AND LEGUME	HARDWOOD FOREST	CONIFEROUS FOREST
Scituate	Fine sandy loam	A,B,C	2	1	1	3
	Very stony fine sandy loam	A,B,C	4	3	1	2
	Extremely stony fine sandy loam	A,B,C	4	4	1	2
Sudbury	Fine sandy loam	A,B	1	1	1	3
Sutton	Fine sandy loam	A,B,C	2	1	1	3
	Very stony fine sandy loam	A,B,C	4	3	1	2
	Extremely stony fine sandy loam	A,B,C	4	4	1	2
Swanton	Fine sandy loam	A,B	3	2	1	2
Walpole	Fine sandy loam	A,B	3	2	1	2
Whitman	Loam	A	4	3	1	1
	Very and Extremely stony loam	A	4	4	1	1
Windsor	Loamy sand	A,B,C	3	3	3	2
		D	4	3	3	2
Winooski	Very fine sandy loam		2	1	1	3
Woodbridge	Fine sandy loam	A,B,C	2	1	1	3
	Very and extremely stony fine sandy loam	A,B,C	4	3	1	3

[1] 1 = well suited
2 = suitable
3 = poorly suited
4 = unsuited

[2] *Grain and seed crops*.--Agricultural grains or seedproducing annuals. Examples are corn, rye, wheat, oat, millet, buckwheat, and sunflowers.

Grasses and legumes.--Domestic perennial grasses and herbaceous legumes. Examples are fescue, bromegrass, bluegrass, timothy, redtop, orchardgrass, reed canarygrass, clover, trefoil, alfalfa, crownvetch, and panicgrass (switchgrass).

Hardwood woody plants.--Nonconiferous trees, shrubs, and woody vines. Examples are oak, beech, cherry, hawthorn, dogwood, viburnum, maple, birch, poplar, grape, honeysuckle, blueberry, brier, autumn-olive, and multiflora rose.

Coniferous wildlife habitat.--Cone-bearing trees and shrubs. Examples are spruce, pine, white-cedar, hemlock, balsam fir, juniper, and yew.

3 Slopes:

A = 0 - 3%
B = 3 - 8%
C = 8 - 15%
D = >15%

Where specific slopes are not presented for a series, the ratings apply for all slopes.

APPENDIX L.

ESTIMATED AVERAGE ACRE YIELDS OF VARIOUS CROPS ON THE MAJOR SOIL SERIES

ESTIMATED AVERAGE ACRE YIELDS OF VARIOUS CROPS[1]

(ADAPTED FROM U. S. SOIL CONSERVATION SERVICE COUNTY SOIL SURVEYS)

SERIES	Sweet Corn (Bu)		SILAGE CORN (Tons)		HAY ALFALFA-BROME (Tons)		HAY TIMOTHY-CLOVER (Tons)		PASTURE IMPROVED COW ACRE DAY[2]		PASTURE NATIVE COW ACRE DAY	
	A	B	A	B	A	B	A	B	A	B	A	B
Acton	35	75	7	15	2	4	2	4	110	220		
Agawam	150-175	225-275	8-10	13-15	2-2.5	4.5-5	1-1.5	3-3.5	70-75	150-200	40	80-90
Au Gres							2	3.5	70	200		
Buxton			9	14			2.5	4.5	80	250	45	95
Canton					NO DATA							
Carver							.5	1.5-2	--	200	20	55
Charlton	125	250	10	15	2.5	5	2	4	70-75	200-225	40	90
Deerfield	100	200	8	16	2	3.5	2.5	4.5	80	250	40	90
Dukes					NO DATA							
Elmwood				20	2	4	2.5	4	115	230		

CONTINUED

CONTINUED

SERIES	SWEET CORN (Bu) A	SWEET CORN (Bu) B	SILAGE CORN (Tons) A	SILAGE CORN (Tons) B	HAY ALFALFA-BROME (Tons) A	HAY ALFALFA-BROME (Tons) B	HAY TIMOTHY-CLOVER (Tons) A	HAY TIMOTHY-CLOVER (Tons) B	PASTURE IMPROVED COW ACRE DAY A	PASTURE IMPROVED COW ACRE DAY B	PASTURE NATIVE COW ACRE DAY A	PASTURE NATIVE COW ACRE DAY B
Enfield	125-175	250	10-14	17-20	3	4.5	2.5	3.5	150	255		
Essex	175	275	9	14	2.4	4.5	2	4	70-75	200-225	40-45	90-95
Hadley	150-175	275-300	10-12	15-18	2.5-3.0	4.5-5.5	2.5	4	75-80	220-225	40	90-95
Hinckley	100	200	6	10	1.5	3	1	2	60	170	25-30	70-80
Hollis							1	2.5	60	180	25-35	70-85
Limerick							2	4	75	200	40	95
Merrimack	100-175	200-275	7-12	11-18	1.5-2.5	3.0-4.5	1.5-2.0	2.5-3.5	50-75	150-300	30-40	70-90
Muck												
Narragansett						NO DATA						
Ninigret	125-150	250	8-10	12-16	2-2.5	4-4.5	2.5	4.5	80	250	45	95-100
Paxton	60	80	14	18-22	2-2.5	4-4.5	2	3.5-4	115	230	95	150
Ridgebury							1	3	150	200	30	75
Saco											30	80

CONTINUED

CONTINUED

SERIES	SWEET CORN (Bu)		SILAGE CORN (Tons)		HAY ALFALFA-BROME (Tons)		HAY TIMOTHY-CLOVER (Tons)		PASTURE IMPROVED COW ACRE DAY		PASTURE NATIVE COW ACRE DAY	
	A	B	A	B	A	B	A	B	A	B	A	B
Saugatuck							2	4	70	150	30	80
Scarboro									70	150	30	80
Scituate	125	250	8-10	12-15	1.5	3.0-3.5	1-1.5	3-4	150	200	40	90
Sudbury	125	250	10	15	2	4	2.5	4.5	80	250	45	95
Sutton	100-125	200-250	10	15	2	4	2-2.5	4-4.5	80	200-225	40	90-95
Swanton				16-18			2	4	70	200	30	80
Walpole							1.5	4	70	200	35	85
Whitman									60	170	20-25	70-80
Windsor	100	200	6-8	10-12	1.5-2	3	1	2	150	200	20-30	40-60
Winooski	175	300	11	16	2.5	5	2	4.5	80	225	45	90
Woodbridge	50	75	12	22	2	4	2	4	115	230		

[1] Yields in columns A are those expected under a low level of management; those in column B are under a moderately high level of management. Absence of yields indicates crop is not usually grown.

[2] Cow acre day is the numbers of days that one acre of pasture can support a 1-cow unit.

APPENDIX M.

ESTIMATED FORESTRY SITE INDEX RANGES ON THE MAJOR SOIL SERIES

ESTIMATED POTENTIAL SOIL
PRODUCTIVITY - FORESTRY SITE INDEX RANGE [1] [2]

(ADAPTED FROM U. S. SOIL CONSERVATION SERVICE COUNTRY SOIL SURVEYS)

SOIL SERIES	NORTHERN HARWOODS	UPLAND OAKS	WHITE PINE	RED PINE
Acton	53 - 58	55 - 64	60 - 69	No Data
Agawam	52 - 57	45 - 64	60 - 69	50 - 69
Au Gres	No Data	55 - 64	60 - 69	70 +
Buxton	52 - 57	55 +	60 - 69	60 +
Canton	No Data			
Carver	<45	<44	<49	<49
Charlton	52 - 57	55 +	60 - 69	60 +
Deerfield	52 - 57	55 - 64	50 - 69	60 - 69
Dukes	No Data			
Elmwood	53 - 58	55 - 64	70 +	No Data
Enfield	No Data	45 - 54	60 - 69	70 +
Essex	52 - 57	55 +	60 - 69	60 +
Hadley	52 - 57	55 +	60 - 69	60 +
Hinckley	46 - 51	45 - 54	50 - 59	50 - 59
Hollis	46 - 57	45 - 54	50 - 59	50 - 59
Limerick	46 - 51	55 - 64	60 - 69	70 +

CONTINUED

CONTINUED

SOIL SERIES	NORTHERN HARWOODS	UPLAND OAKS	WHITE PINE	RED PINE
Merrimac	52 - 57	45 - 64	60 - 69	50 - 59
Muck	<45	NS	50 - 59	NS
Narragansett		No Data		
Ninigret	52 - 57	55 +	60 - 69	60 +
Paxton	59 +	65 +	60 - 69	No Data
Ridgebury	59 +	65 +	70 +	70 +
Saco	<45	NS	50 - 59	NS
Saugatuck	45 - 52	45 - 54	60 - 69	50 - 59
Scarboro	<45	NS	50 - 59	NS
Scituate	52 - 57	55 +	60 - 69	60 +
Sudbury	52 - 57	55 - 64	50 - 59	60 - 69
Sutton	52 - 57	55 +	60 - 69	60 +
Swanton	46 - 51	55 - 64	60 - 69	70 +
Walpole	46 - 51	55 - 64	60 - 69	70 +
Whitman	<45	NS	50 - 59	NS
Windsor	46 - 51	45 - 54	50 - 59	50 - 69
Winooski	58 +	65 +	70 +	70 +
Woodbridge	59 +	65 +	70 +	No Data

[1] Site Index is the average height of the dominant and codominant trees in a fully stocked unmanaged stand at the age of 50 years.

[2] NS = Not Suitable

APPENDIX N.

AQUATIC IMPACTS OF WASTEWATER TREATMENT ALTERNATIVES

AQUATIC IMPACTS OF WASTEWATER TREATMENT ALTERNATIVES

The localized impact of both secondary and AWT effluent water entering natural surface waters will, of course, be much less than that of untreated or primarily treated effluent. However, they will have an impact on the biota. These impacts are discussed below relative to the predicted general characteristics of the receiving stream after the institution of the level of treatment being discussed.

I. LOCAL EFFECTS

A. Secondarily Treated Effluent (see Figure 3., Table 10).

1. Physical -- There is likely to be a local increase in turbidity. The overall impact on all biological communities of this environmental alteration is probably neutral.

2. Chemical

a. Primary Productivity -- Unless inhibited by phytotoxic materials (Hg, Mn, and Ni), an increase in periphyton and aquatic macrophyte production is forseen in the immediate vicinity of the outfall due to locally increased nutrient availibility. It is likely that this zone of increased primary productivity will also biomagnify some heavy metals present in the effluent discharge.

b. Invertebrates -- Invertebrate organisms (zooplankton, macro-, and micro-benthos) will be subject to a variety of materials at toxic concentrations (e.g. NH_3, residual Cl_2, and Metals). It is expected that more sensitive organisms will not be able to establish viable populations in the immediate vicinity of the outfall, and that those organisms that do survive will have limited reproductive success due to the action of toxic materials. It is also expected that invertebrate organisms in the immediate vicinity of the outfall will biomagnify some heavy metals present in the wastewater effluent.

c. Fish -- Fish species sensitive to ammonia, chlorine, and other effluent constituents (typically game and forage fish) will probably avoid the immediate vicinity of the discharge, while rough fish may locally increase in relative abundance. Those fish which remain in the immediate vicinity of the discharge are likely to suffer chronic sublethal effects from toxic materials present in the discharge (e.g. tainting of edible species, reduced reproductive success,

reduced viability, etc.).

3. Magnitude of Localized Effects

The magnitude of localized impacts will be dependent upon the volume of wastewater impact relative to river discharge. As indicated by Table 9., the greatest localized impacts would be expected to occur in the Merrimack River at the Lawrence, Massachusetts discharge, while the smallest will occur at the Merrimack, Massachusetts discharge.

TABLE 10.
STATE IMPLEMENTATION PLAN. PERCENT OUTFALL CONTRIBUTION TO 10 DAY - 7 YEAR LOW FLOW.

Outfall Location	Discharge (MGD)	Receiving Stream	% 7 Day-10 Year Low Flow
Billerica	1.60	Concord River	8.83
Lowell	31.60	Merrimack River	5.53
Lawrence	52.00	Merrimack River	8.80
Haverhill	18.11	Merrimack River	3.60
Merrimack	0.53	Merrimack River	0.09
Amesbury	1.90	Merrimack River	0.32

B. Advanced Wastewater Treatment Effluent (See Figures 3-8, Table 11).

1. Physical -- There is likely to be a local increase in turbidity. The overall impact on all biological communities of this environmental alteration is probably neutral.

2. Chemical

a. Primary Productivity -- Localized increases in periphyton and aquatic macrophyte production due to nutrient enrichment. According to effluent specifications for AWT, no phytotoxic materials are expected in the effluent.

b. Invertebrates -- Invertebrate organisms (zooplankton, macro-, and micro-benthos) may be locally subjected to toxic action from ammonia, residual chlorine, and

chloramines. This toxic action may prevent more sensitive organisms from establishing a viable population in the immediate vicinity of the outfall, and possibly reduce the reproductive success of less sensitive forms.

c. Fish -- Fish sensitive to ammonia, residual chlorine, and chloramines will probably avoid the immediate vicinity of the discharge, consequently, less sensitive rough species may locally increase in relative abundance. Those fish which remain in the immediate vicinity of the effluent may possibly suffer from decreased reproductive success and decreased viability.

3. Magnitude of Local Effects

The magnitude of local effects will be dependent upon the volume of wastewater inflow relative to river discharge (see Table 11).

TABLE 11.
ADVANCED WASTEWATER TREATMENT ALTERNATIVES
PERCENT OUTFALL CONTRIBUTION TO 7 DAY-10 YEAR LOW FLOW.

ALTERNATIVE 1

Water Oriented Decentralized

Outfall Location	Discharge (MGD)		Receiving Stream	% 7 Day-10 Year Low Flow	
	1990	2020		1990	2020
Billerica	7.25	12.43	Concord River	40.05	68.67
Amesbury	1.86	3.31	Powwow River	58.62	104.32
North Chelmsford	0.81	6.71	Merrimack River	00.14	1.17
Lowell	24.12	33.10	Merrimack River	4.08	5.60
Lawrence	43.61	60.12	Merrimack River	7.38	10.18
Haverhill	13.19	19.50	Merrimack River	2.23	3.30
Newburyport	3.05	4.45	Estuary or Ocean	0.52	0.75
Salisbury	1.67	2.13	Estuary or Ocean	0.28	0.36

ALTERNATE 2

Water Oriented Partially Decentralized

Outfall Location	Discharge (MGD) 1990	2020	Receiving Stream	% 7 Day-10 Year Low Flow 1990	2020
Lowell	32.18	52.24	Merrimack River	5.44	8.84
Lawrence	43.61	59.25	Merrimack River	7.38	10.03
Haverhill	13.19	19.50	Merrimack River	2.23	3.30
Amesbury	1.55	2.36	Merrimack River	0.26	0.40

ALTERNATE 3

Water Oriented Centralized

Outfall Location	Discharge (MGD) 1990	2020	Receiving Stream	% 7 Day-10 Year Low Flow 1990	2020
Concord	32.18	52.24	Concord River	177.74	288.62
Lawrence	56.80	80.21	Merrimack River	9.61	13.57
Newburyport	6.58	10.32	Estuary	1.11	1.75

ALTERNATE 4

Water Oriented Regional

Outfall Location	Discharge (MGD) 1990	2020	Receiving Stream	% 7 Day-10 Year Low Flow 1990	2020
Lawrence	88.98	132.45	Merrimack River	15.06	22.41
Newburyport	6.58	10.32	Estuary	1.11	1.75

ALTERNATES 5 AND 6

Land Alternatives

Outfall Location	Discharge (MGD)		Receiving Stream	% 7 Day-10 Year Low Flow	
	1990	2020		1990	2020
Lawrence	43.61	60.12	Merrimack River	7.38	10.17
Newburyport*	3.05	4.45	Estuary	0.52	0.75

* Secondary Effluent

II. GENERAL EFFECTS

A. State Implementation Plan - Secondary Treatment (See Figure 3, Table 12).

1. Physical

a. Concord River -- Increased water inputs will tend to stabilize summer low flows in the Concord River below the Billerica outfall. Such a flow stabilization will have a generally positive effect on the river. This flow increase could possibly increase dissolved oxygen and reduce solar heating of the stream during periods of low flow. No significant impact on stream turbidity is expected.

b. Powwow River -- Absence of wastewater effluent in the Powwow River will reduce flows, however, it is not expected to significantly alter the physical environment.

c. Merrimack River, Area I -- No expected impact.

d. Merrimack River, Area II -- No impacts expected.

e. Merrimack River, Area III -- Expect reductions in turbidity levels and consequently greater light penetration.

f. Merrimack River Estuary -- No substantial impacts expected.

2. Chemical

a. Concord River

aa. Primary productivity -- Since the Concord River is already a highly enriched stream, no net increase or decrease of production by phytoplankton, periphyton or aquatic macrophytes is expected. These communities would be expected to biomagnify some heavy metals present in the effluent. Some phytotoxic action by mercury is possible.

bb. Invertebrates -- No substantial change in the invertebrate community is expected in the affected area of the Concord River. Although biochemical oxygen demand will be reduced, resynthesis of organic materials from available nutrients and their subsequent decay will tend to negate the effect of biochemical oxygen

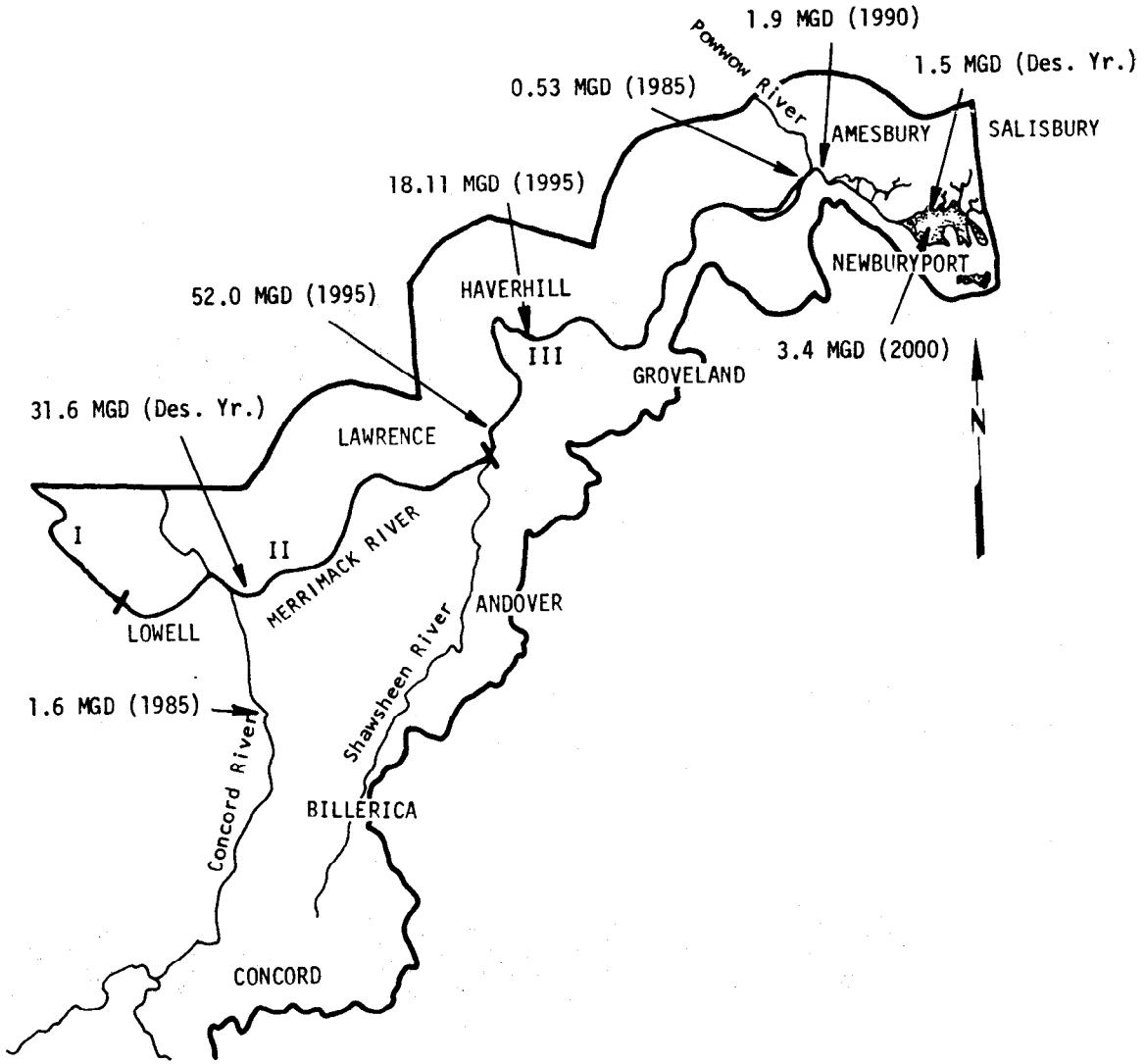

Figure 3. Wastewater inputs to the aquatic ecosystem - state secondary implementation program. MGD = Million gallons / day

TABLE 12.

SECONDARY IMPLEMENTATION PLAN

PARAMETER	OUTFALL CONC. (ppm)	BASELINE RIVER CONC.		CONCENTRATIONS AFTER MIXING				CRITERIA (EPA AND SCIENTIFIC LITERATURE) (ppm)
		CONCORD RIVER (ppm)	MERRIMACK RIVER (ppm)	CONCORD RIVER (ppm)	MERRIMACK RIVER			
					AREA I STATE LINE TO PAWTUCKET DAM (ppm)	AREA II PAWTUCKET DAM TO ESSEX DAM (ppm)	AREA III ESSEX DAM TO ESTUARY (ppm)	
Total Nitrogen	20	--[1]	3.5	1.6	3.5	4.2	5.45-5.88	--
Organic Nitrogen	2.0	--[1]	1.9	0.16	1.9	1.82	1.83-1.83	--
Ammonia	9.8	0.2	0.5	0.98	0.5	0.98	1.66-1.90	.02
Nitrite	0.0	--[1]	.02	---[1]	.02	---[1]	----[1]	--
Nitrate	8.2	0.3	1.1	0.94	1.1	1.45	1.97-2.13	.3
Total Phosphorous	10.0	0.2	.07	0.9	.07	.097	1.32-1.58	.05
Phenols	0.3	--[1]	--	.02	---[1]	.0158	.0377-.0454	.001
Cadmium	0.1	--[1]	0.0	.008	0.0	.0053	.0126-.0152	.004-.0004

CONTINUED

TABLE 12. CONTINUED

PARAMETER	OUTFALL CONC. (ppm)	BASELINE RIVER CONC.		CONCENTRATIONS AFTER MIXING				CRITERIA (EPA AND SCIENTIFIC LITERATURE) (ppm)
		CONCORD RIVER (ppm)	MERRIMACK RIVER (ppm)	CONCORD RIVER (ppm)	MERRIMACK RIVER			
					AREA I STATE LINE TO PAWTUCKET DAM (ppm)	AREA II PAWTUCKET DAM TO ESSEX DAM (ppm)	AREA III ESSEX DAM TO ESTUARY (ppm)	
Chromium	0.2	--[1]	.007	.016	.007	.0107	.0253-.0304	0.01
Copper	0.1	--[1]	.012	.008	.012	.0164	.023-.025	.05
Lead	0.1	--[1]	..005	.008	.005	.0098	.0167-.0192	.05
Manganese	0.2	--[1]	0.72	.016	0.72	.67	.62-.64	.1
Mercury	.005	--[1]	---	.00041	---[1]	.00026	.00063-.00076	.00005
Nickel	0.2	--[1]	.004	.016	.004	.0104	.020-.022	0.1
Zinc	0.2	--[1]	0.010	.016	.010	.0196	.0335-.0384	0.1

demand removal. Expected cadmium concentrations are likely to reduce the fecundity of micro-invertebrates (e.g. *Daphnia* spp.), and be biomagnified by macroinvertebrates. Mercury, although not expected to occur at an acutely toxic level, could exert chronic sublethal effects on the invertebrate community. Other metals are likely to be biomagnified by invertebrates and have synergystic effects. Chronic sublethal effects of these metals on invertebrate organisms are not well studied.

cc. Fish -- The fisheries population existing in the Concord River is expected to be neutrally impacted by the institution of secondary treatment at Billerica, as no substantial change in dissolved oxygen or toxicant levels is expected. Expected phenolic residues could possibly taint edible fish. Cadmium is not expected to occur in concentrations which would be acutely toxic to adult fish, however, it could be toxic to the more sensitive eggs and larvae. Mercury could possibly occur in concentrations which would be toxic to sensitive fish species. It is expected that the fisheries community will biomagnify all heavy metals. The expected mercury concentrations are such that biomagnification of this metal could reduce gamefish utility.

dd. Summary -- No substantial environmental improvements can be forseen after the institution of secondary level treatment for wastewater entering the Concord River at Billerica. This is largely due to projected increased wastewater inputs. It must be pointed out, however, that without at least secondary treatment, increased wastewater flows would likely have a highly negative impact on the Concord River ecosystem.

b. Powwow River -- No secondary wastewater outfalls are located on this river, hence the state implementation plan would have a neutral to somewhat positive impact on the Powwow River ecosystem.

c. Merrimack River, Area I -- No secondary wastewater outfalls are located on this stretch of river, thus a neutral or somewhat positive environmental impact is expected for this area.

d. Merrimack River Area II

aa. Primary Productivity -- Increased wastewater flows without nutrient removal could cause increased primary productivity behind the Essex Dam at Lawrence, Massachusetts. Some phytotoxic action can be expected from metal ions introduced by the effluent water.

bb. Invertebrates -- No substantial change in the invertebrate community is expected in Area II of the Merrimack River. Although biochemical oxygen demand will be reduced, resynthesis of organic materials from available nutrients and their subsequent decay could tend to negate the effect of biochemical oxygen demand removal. Expected cadmium concentrations are likely to reduce the fecundity of microinvertebrates (e.g. *Daphnia* spp.), and be biomagnified by macroinvertebrates. Mercury, although not expected to occur at an acutely toxic level, could exert chronic sublethal effects on the invertebrate community. Other metals are likely to be biomagnified by invertebrates and have synergystic effects. Chronic sublethal effects of these metals on invertebrate organisms are not well studied.

cc. Fish -- The fisheries population existing in Area II of the Merrimack River is expected to be neutrally impacted by the institution of secondary treatment, as no substantial change in dissolved oxygen or toxicant levels is expected. Expected phenolic residues could possibly taint edible fish. Cadmium is not expected to occur in concentrations which would be acutely toxic to adult fish, however, it could be toxic to the more sensitive eggs and larvae. Mercury could possibly occur in concentrations which would be toxic to sensitive fish species. It is expected that the fisheries community will biomagnify all heavy metals. The expected mercury concentrations are such that biomagnification of this metal could reduce gamefish utility. Below Lawrence the secondary effluent

will comprise 23.16% of the 7-day 10 year low flow. Such a concentration of secondary effluent is known to taint fish flesh, and this effect is expected to occur in the Merrimack River below Lawrence.

dd. Summary -- No substantial environmental improvements can be forseen after the institution of secondary level treatment for wastewater entering Area II of the Merrimack River. This is largely due to projected increased wastewater inputs. It must be pointed out, however, that without at least secondary treatment, increased wastewater flows would likely have a highly negative impact on the biota of Area II.

e. Merrimack River, Area III

aa. Primary Productivity -- Increased flows of wastewater without nutrient removal and decreased turbidity could increase primary productivity in the tidally impounded Area III of the Merrimack River, unless phytotoxic materials become concentrated in this impounded section.

bb. Invertebrates -- No substantial change in the invertebrate community is expected in Area III of the Merrimack River. Although biochemical oxygen demand will be reduced, resynthesis of organic materials from available nutrients and their subsequent decay will tend to negate the effect of biochemical oxygen demand removal. Expected cadmium concentrations are likely to reduce the fecundity of microinvertebrates (e.g. Daphnia spp.), and be biomagnified by macroinvertebrates. Mercury, although not expected to occur at an acutely toxic level, could exert chronic sublethal effects on the invertebrate community. Other metals are likely to be biomagnified by invertebrates and have synergistic effects. Chronic sublethal effects of these metals on invertebrate organisms are not well studied.

cc. Fish -- The fisheries population existing in Area III of the Merrimack River is expected to be neutrally impacted by the institution of secondary treatment. Although it is likely that dissolved oxygen conditions will be some-

what improved, no change in toxicant levels is expected. Expected phenolic residues could possibly taint edible fish. Cadmium is not expected to occur in concentrations which would be acutely toxic to adult fish, however, it could be toxic to the more sensitive eggs and larvae. Mercury could possibly occur in concentrations which would be toxic to sensitive fish species. It is expected that the fisheries community will biomagnify all heavy metals. The expected mercury concentrations are such that biomagnification of this metal could reduce gamefish utility.

dd. Summary -- No substantial environmental improvements can be forseen after the institution of secondary level treatment for wastewater inputs. It must be pointed out, however, that without at least secondary treatment, increased wastewater flows would likely have a highly negative impact on the biota of Area III.

f. Merrimack River Estuary -- Since secondary treatment of wastewater removes biochemical oxygen demand and suspended solids, but provides little or no reduction of nutrients and various toxic materials, the overall impact of the projected increased waste loading of the Merrimack River on the Merrimack River Estuary, at the time of secondary implementation, will be negative. Direct discharge of secondary treated waste from Newburyport and Salisbury into the Estuary is expected to have a negative impact. Ammonia is likely to remain toxic for a longer period of time due to the higher alkalinity of the estuarine water. Residual chlorine and chloramines will probably have toxic, sublethal effects on various estuarine organisms. Finally, chronic sublethal effects of heavy metals will have a deleterious effect on estuarine organisms.

B. Alternate 1. Water Oriented, Decentralized - Advanced Wastewater Treatment (see Figure 4, Table 13).

1. Physical

a. Concord River -- Increased water inputs will tend to stabilize summer low flows in the Concord River below the Billerica outfall. Such a flow stabilization will have a positive environmental impact on the river. This flow increase could possibly increase dissolved oxygen and reduce solar heating during periods of low flow. No

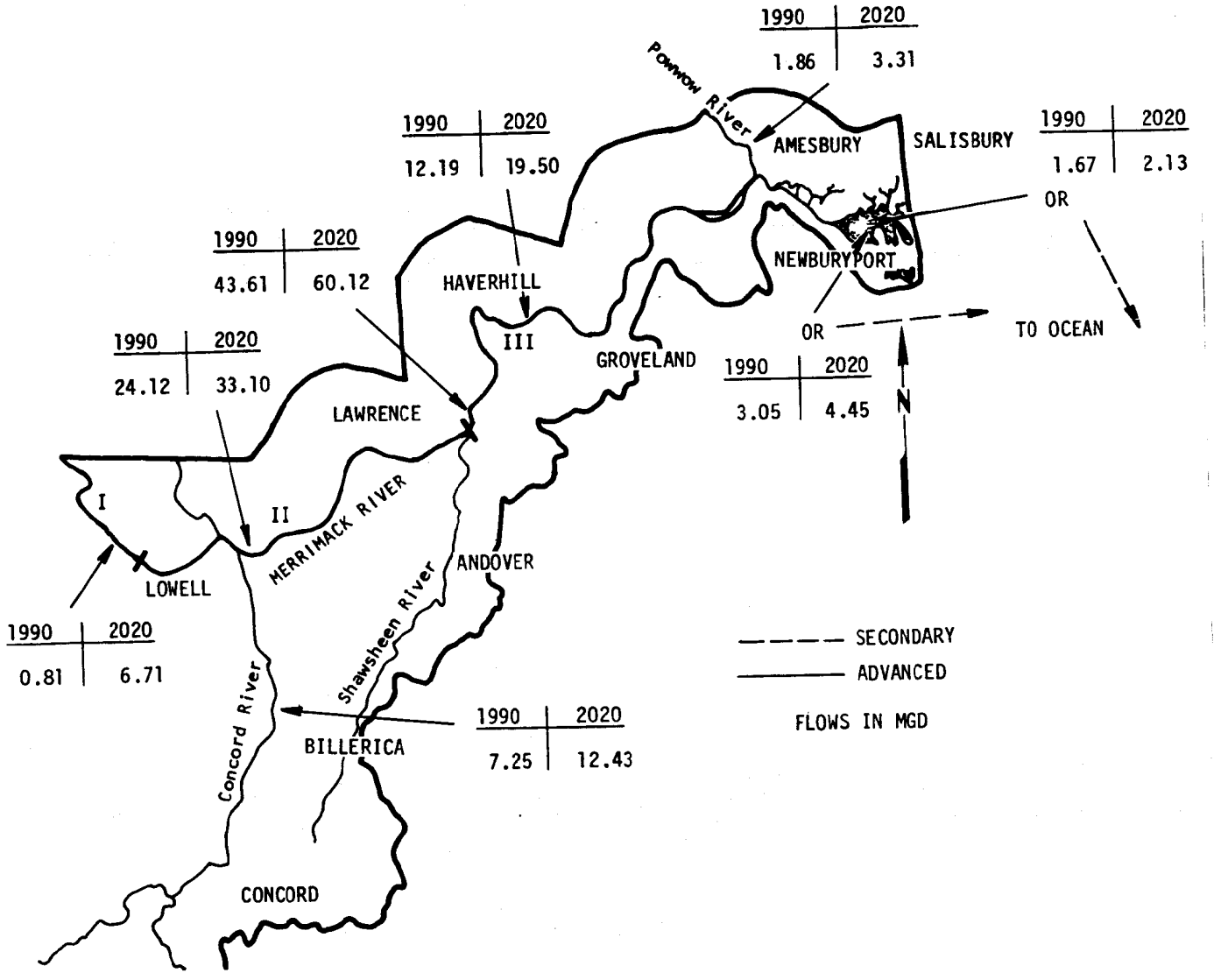

Figure 4. Wastewater inputs to the aquatic ecosystem - Alternate 1. Water oriented decentralized.

TABLE 13.
ALTERNATE 1, WATER ORIENTED DECENTRALIZED

PARAMETER	OUTFALL CONC. (ppm)	BASE LINE RIVER CONC.[1] CONCORD RIVER (ppm)	POWWOW RIVER (ppm)	MERRIMACK RIVER (ppm)	CONCENTRATIONS AFTER MIXING: CONCORD RIVER 1990 (ppm)	CONCORD RIVER 2020 (ppm)	POWWOW RIVER 1990 (ppm)	POWWOW RIVER 2020 (ppm)	MERRIMACK RIVER: AREA I STATE LINE TO PAWTUCKET DAM 1990 (ppm)	AREA I 2020 (ppm)	AREA II PAWTUCKET DAM TO ESSEX DAM 1990 (ppm)	AREA II 2020 (ppm)	AREA III ESSEX DAM TO ESTUARY 1990 (ppm)	AREA III 2020 (ppm)	CRITERIA (EPA AND SCIENTIFIC LITERATURE) (ppm)
Total Nitrogen	2.0	---[2]	---[2]	.35	.57	.81	.74	1.02	.35	.37	.42	.47	.52-.55	.63-.64	---[3]
Organic Nitrogen	.5	---[2]	---[2]	.5	.14	.20	.184	.225	0.5	0.5	.485	.486	.486-.481	.513 .485	---[3]
Ammonia	.5	.024	---[2]	.025	.16	.22	.184	.225	.026	.030	.049	.064	.078-.087	.106-.112	.02
Nitrate	1.0	.03	.01	.13	.31	.42	.37	.515	.13	.14	.17	.198	.22-.240	.28-.288	.3
Total Phosphate	.05	.0001	.001	.0055	.014	.020	.019	.026	.0042	.0092	.0029	.0044	.0059-.0069	.0087-.0096	.05

[1] Above First outfall -- determined from existing conditions and projected upstream flows and treatment level.
[2] No data available.
[3] No criteria set.

significant impact on stream turbidity is expected.

b. Powwow River -- Increased water inputs will tend to stabilize summer low flows in the Powwow River. Such a flow stabilization will have a positive environmental impact and could possibly improve dissolved oxygen levels and reduce solar heating during periods of low flow. No significant impact on stream turbidity is expected.

c. Merrimack River, Area I -- No substantial environmental impact.

d. Merrimack River, Area II -- No substantial environmental impact.

e. Merrimack River, Area III -- Expect reduction in turbidity and consequently increased light penetration.

f. Merrimack River Estuary -- No substantial environmental impact.

2. Chemical

a. Concord River

aa. Primary Productivity -- No substantial impact is expected since the system is already highly enriched naturally.

bb. Invertebrates -- Removal of toxic metals from wastewater effluent will permit more sensitive invertebrate organisms to proliferate in the Concord River.

cc. Fish -- Removal of toxic metals from wastewater effluent will permit more sensitive fish (game fish) to proliferate in the Concord River.

dd. Summary -- Substantial improvement over existing conditions because of flow augmentation and removal of toxic materials. Toxicity problems of ammonia and residual chlorine will have some negative environmental impact, however.

b. Powwow River

aa. Primary Productivity -- Although some reduction of primary productivity is expected no substantial impact is predicted since the system is already highly enriched from natural sources.

bb. Invertebrates -- Removal of toxic metals from wastewater effluent will permit more sensitive invertebrate organisms to proliferate in the Powwow River. During periods of low flow, the wastewater discharge contemplated by this alternative will dominate the river flow. Under such conditions, it is likely that ammonia and residual chlorine will approach toxic levels.

cc. Fish -- Removal of toxic metals from wastewater effluent will permit more sensitive fish (game fish) to proliferate in the Powwow River. During periods of low flow, the wastewater discharge contemplated by this alternative will dominate the river flow. Under such conditions, it is likely that ammonia and residual chlorine will approach toxic levels in the Powwow River.

dd. Summary -- Substantial improvement over existing conditions because of flow augmentation and removal of toxic materials. Toxicity problems of ammonia and residual chlorine will have some negative environmental impact, however.

c. Merrimack River, Area I -- Only local effects will operate in this area. The effluent discharge (1990, 2020) is too small to substantially alter general water chemistry.

d. Merrimack River, Area II -- Local impacts will dominate. Some chance of ammonia and chlorine toxicity to invertebrates and fish during low flows.

e. Merrimack River, Area III -- Local impacts will dominate. Greater chance for ammonia and chlorine toxicity than in Area II due to tidal impoundment and heavier waste loading.

C. Alternate 2, Water Oriented, Partially Decentralized (see Figure 5, Table 14).

1. Physical -- No substantial physical impact forseen on any stream -- would expect turbidity reduction in Merrimack River, Area III.

2. Chemical

a. Concord River -- Removal of wastewater discharges will have a positive impact.

aa. Primary Productivity -- No substantial impact is expected since the system is already highly enriched naturally.

bb. Invertebrates -- Removal of toxic materials input will permit more sensitive invertebrate organisms to proliferate in the Concord River.

cc. Fish -- Removal of toxic materials input will permit more sensitive fish (game fish) to proliferate in the Concord River.

dd. Summary -- Substantial improvement over existing conditions because of removal.

b. Powwow River -- Removal of wastewater inputs will have positive impact.

aa. Primary Productivity -- Although some reduction of primary productivity is expected no substantial impact is predicted since the system is already highly enriched from natural sources.

bb. Invertebrates -- Removal of toxic materials will permit more sensitive invertebrate organisms to proliferate in the Powwow River.

cc. Fish -- Removal of toxic materials will permit more sensitive (game fish) to proliferate in the Powwow River.

dd. Summary -- Substantial improvement over existing conditions because of toxic materials removal.

c. Merrimack River Area I -- Removal of wastewater inputs will have a positive impact.

aa. Primary Productivity -- Removal of wastewater inputs should decrease primary productivity.

bb. Invertebrates -- Removal of toxic materials will permit more sensitive invertebrate organisms to proliferate in this section of the Merrimack River.

cc. Fish -- Removal of toxic materials will permit more sensitive fish (gamefish) to proliferate in this section the Merrimack River.

dd. Summary -- Substantial improvement over existing conditions because of toxic materials removal.

d. Merrimack River, Area II -- Local impacts will dominate. Some chance of ammonia and chlorine toxicity to invertebrates and fish during low flows.

e. Merrimack River, Area III -- Local impacts will dominate. Greater chance for ammonia and chlorine toxicity than in Area II due to tidal impoundment and heavier waste loading.

f. Merrimack River Estuary -- Removal of wastewater inputs will have a positive impact.

g. Summary -- Impacts will increase in 2020 over 1990, but no substantial change is foreseen -- generally expect substantial improvement over existing conditions.

D. Alternate 3, Water Oriented, Centralized (see Figure 6, Table 15)

1. Physical

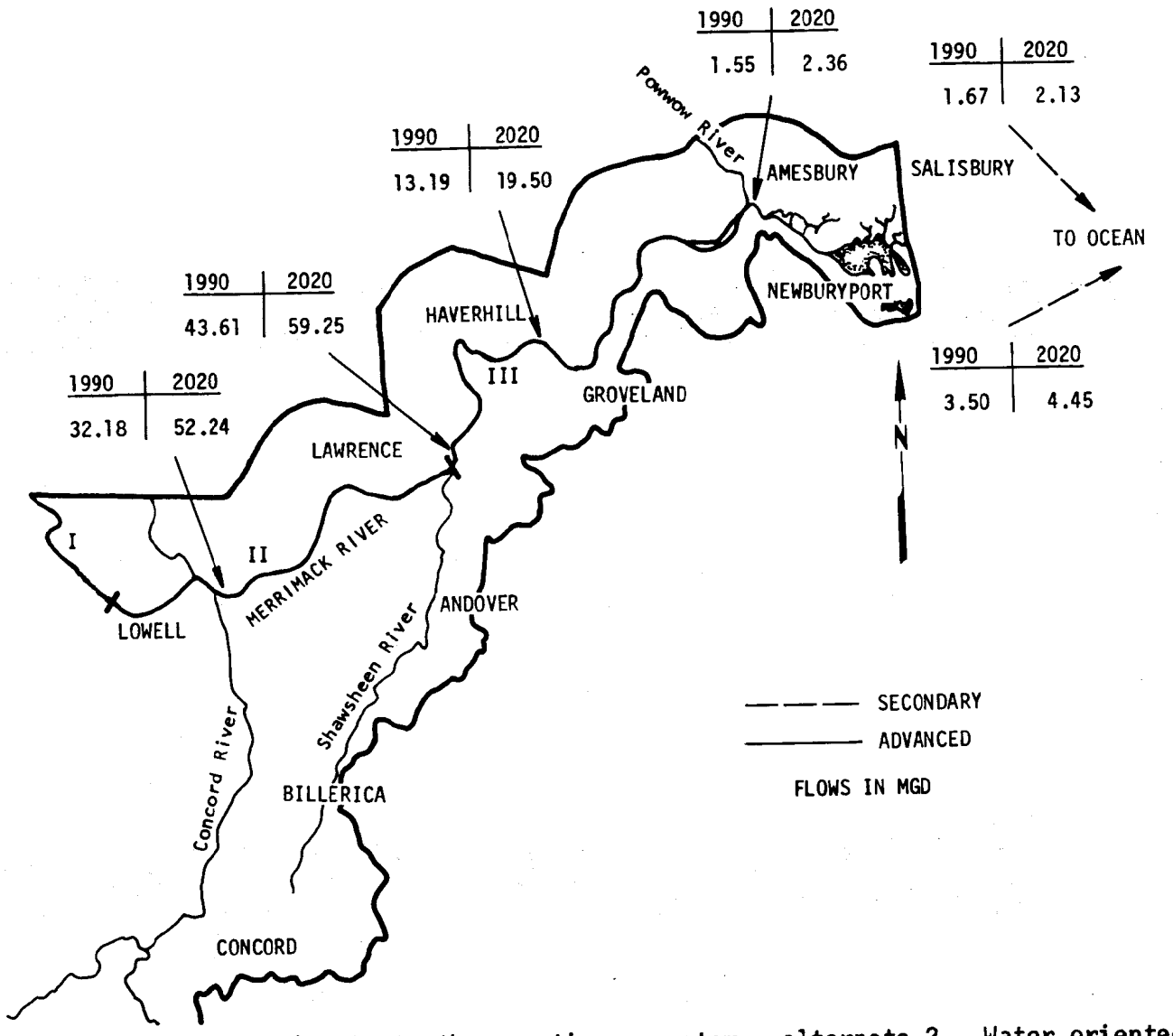

Figure 5. Wastewater inputs to the aquatic ecosystem - alternate 2. Water oriented partially decentralized.

TABLE 14.
ALTERNATE 2, WATER ORIENTED PARTIALLY DECENTRALIZED

PARAMETER	OUTFALL CONC. (ppm)	BASE LINE RIVER CONC.[1]			CONCENTRATIONS AFTER MIXING										CRITERIA (EPA AND SCIENTIFIC LITERATURE) (ppm)
					CONCORD RIVER		POWWOW RIVER		MERRIMACK RIVER						
									AREA I STATE LINE TO PAWTUCKET DAM		AREA II PAWTUCKET DAM TO ESSEX DAM		AREA III ESSEX DAM TO ESTUARY		
		CONCORD RIVER (ppm)	POWWOW RIVER (ppm)	MERRIMACK RIVER (ppm)	1990 (ppm)	2020 (ppm)	1990 (ppm)	2020 (ppm)	1990 (ppm)	2020 (ppm)	1990 (ppm)	2020 (ppm)	1990 (ppm)	2020 (ppm)	
Total Nitrogen	2.0	---[2]	---[2]	.35					.35	.35	.435	.50	.54-.57	.63-.67	---[3]
Organic Nitrogen	.5	---[2]	---[2]	.5					.5	.5	.5	.5	.5	.5	---[3]
Ammonia	.5	.024	---[2]	.025					.025	.025	.049	.064	.079-.088	.100-.112	.02
Nitrate	1.0	.03	.01	.13					.13	.13	.17	.20	.23-.246	.27-.29	.3
Total Phosphate	.05	.0001	.001	.0055					.0035	.0035	.0059	.0073	.0088-.0097	.0108-.0102	.05

[1] Above First outfall -- determined from existing conditions and projected upstream flows and treatment level.
[2] No data available.
[3] No criteria set.

a. Concord River -- A substantial flow augmentation is expected which will tend to stabilize low summer flows in the Concord River. Such flow augmentation could possibly improve dissolved oxygen conditions and reduce solar heating in summer low flow periods. No substantial impact on turbidity is expected, however a slight increase might be expected.

b. Powwow River -- No effect.

c. Merrimack River, Areas I, II, III, and Merrimack River Estuary -- No significant effect, with exception of lowered turbidity levels in Area III.

2. Chemical

a. Concord River

aa. Primary Productivity -- No substantial impact is expected since the system is already highly enriched naturally.

bb. Invertebrates -- Removal of toxic metals from wastewater effluent will permit more sensitive invertebrate organisms to proliferate in the Concord River. During periods of low flow, the wastewater discharge contemplated by this alternative will dominate the river flow. Under such conditions, it is likely that ammonia and residual chlorine will approach toxic levels in the Concord River below the outfall at Concord.

cc. Fish -- Removal of toxic metals from wastewater effluent will permit more sensitive fish (game fish) species to proliferate in the Concord River. During periods of low flow, the wastewater discharge contemplated by this alternative will dominate the river flow. Under such conditions, it is likely that ammonia and residual chlorine will approach toxic levels in the Concord River below Concord.

dd. Summary -- Substantial improvement over existing conditions should result because of flow augmentation and removal of toxic materials. Toxicity problems of ammonia and residual chlorine will have some negative environmental impact, however.

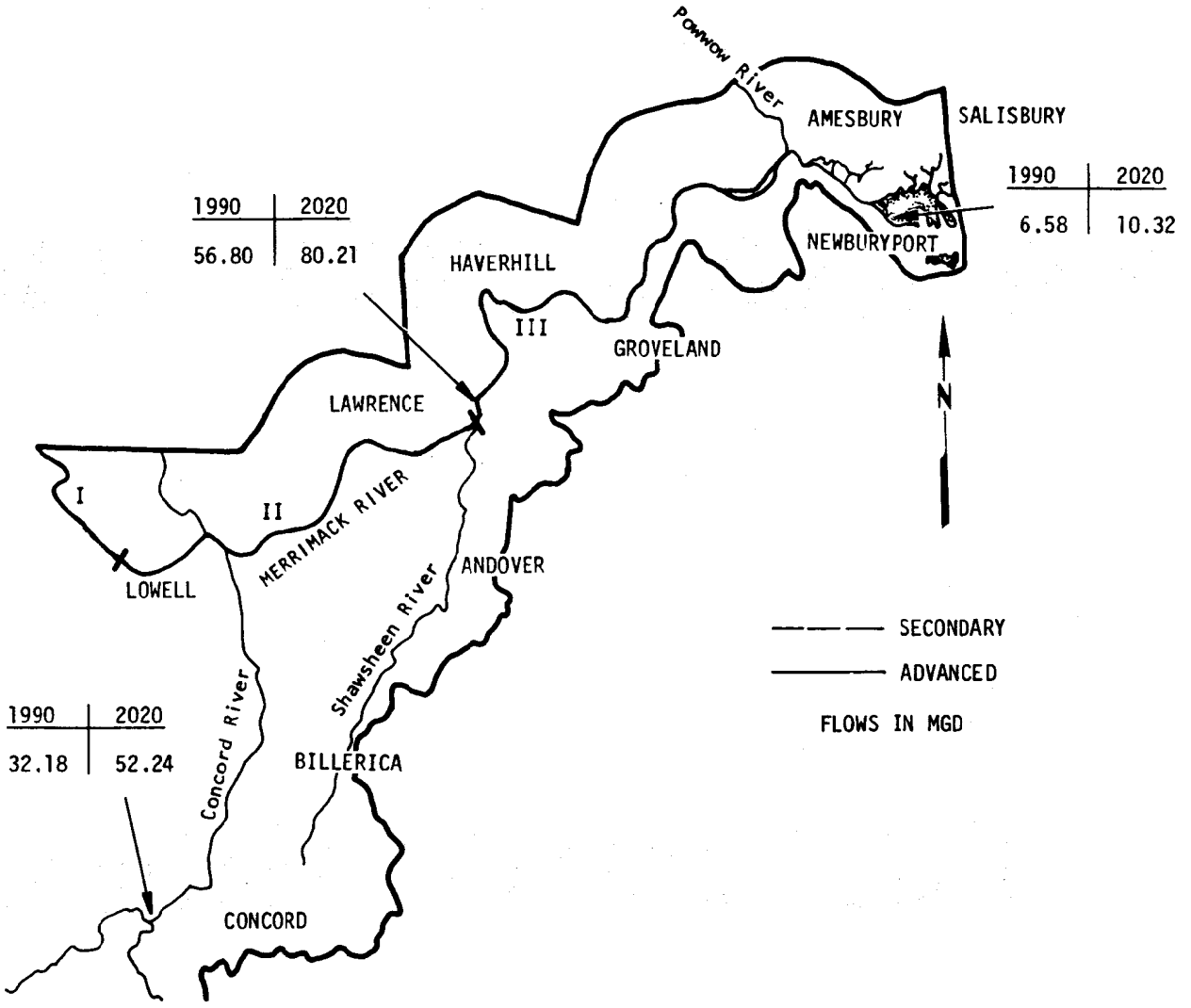

Figure 6. Wastewater inputs to the aquatic ecosystem - alternate 3. Water oriented centralized.

TABLE 15.
ALTERNATE 3, WATER ORIENTED CENTRALIZED

PARAMETER	OUTFALL CONC. (ppm)	BASE LINE RIVER CONC.[1]			CONCENTRATIONS AFTER MIXING										CRITERIA (EPA AND SCIENTIFIC LITERATURE) (ppm)
									MERRIMACK RIVER						
					CONCORD RIVER		POWWOW RIVER		AREA I STATE LINE TO PAWTUCKET DAM		AREA II PAWTUCKET DAM TO ESSEX DAM		AREA III ESSEX DAM TO ESTUARY		
		CONCORD RIVER (ppm)	POWWOW RIVER (ppm)	MERRIMACK RIVER (ppm)	1990 (ppm)	2020 (ppm)	1990 (ppm)	2020 (ppm)	1990 (ppm)	2020 (ppm)	1990 (ppm)	2020 (ppm)	1990 (ppm)	2020 (ppm)	
Total Nitrogen	2.0	---[2]	---[2]	.35	1.28	1.49	---	---	.35	.35	.42	.47	.56	.64	---[3]
Organic Nitrogin	.5	---[2]	---[2]	.5	0.32	0.37	---	---	.5	.5	.485	.485	.486	.487	---[3]
Ammonia	.5	.024	---[2]	.025	.33	.38	---	---	.025	.025	.0445	.0635	.0871	.1119	.02
Nitrate	1.0	.03	.01	.13	.65	.75	---	---	.13	.13	.17	.19	.24	.28	.3
Total Phosphate	.05	.0001	.001	.0035	.032	.037	---	---	.0035	.0035	.0058	.0072	.0095	.012	.05

1 Above First outfall -- determined from existing conditions and projected upstream flows and treatment level.
2 No data available.
3 No criteria set.

b. Powwow River -- Removal of wastewater effluent will have a positive environmental impact.

c. Merrimack River Area I -- Removal of wastewater effluent will have a positive effect.

d. Merrimack River, Area II -- Local impacts in the vicinity of the Concord River mouth. No substantial environmental impacts are expected.

e. Merrimack River, Area III -- Local effects will dominate. However, there is some chance for ammonia and chlorine toxicity during periods of low flow.

f. Merrimack River Estuary -- Discharge of AWT effluent to the Estuary will have primarily a localizing impact.

g. Summary -- Impacts will increase in 2020 over 1990, however, no substantial change is forseen. A substantial improvement over existing conditions may be expected.

E. Alternate 4, Water Oriented, Regional (see Figure 7, Table 16).

1. Physical

a. Concord River -- Removal of wastewater input will have a positive environmental effect.

b. Powwow River -- Removal of wastewater input will have a positive environmental impact.

c. Merrimack River Area I -- Removal of wastewater inputs will have a positive environmental impact.

d. Merrimack River Area II -- Removal of wastewater inputs will have a positive environmental impact.

e. Merrimack River Area III -- There will be a very large local impact at the Lawrence outfall. Because of increased effluent values and decreased distance for river assimilation, the environmental impacts of this alternatate will be increased over other alternates.

f. Merrimack River Estuary -- Ingestion of AWT effluent is not expected to have a negative impact and im-

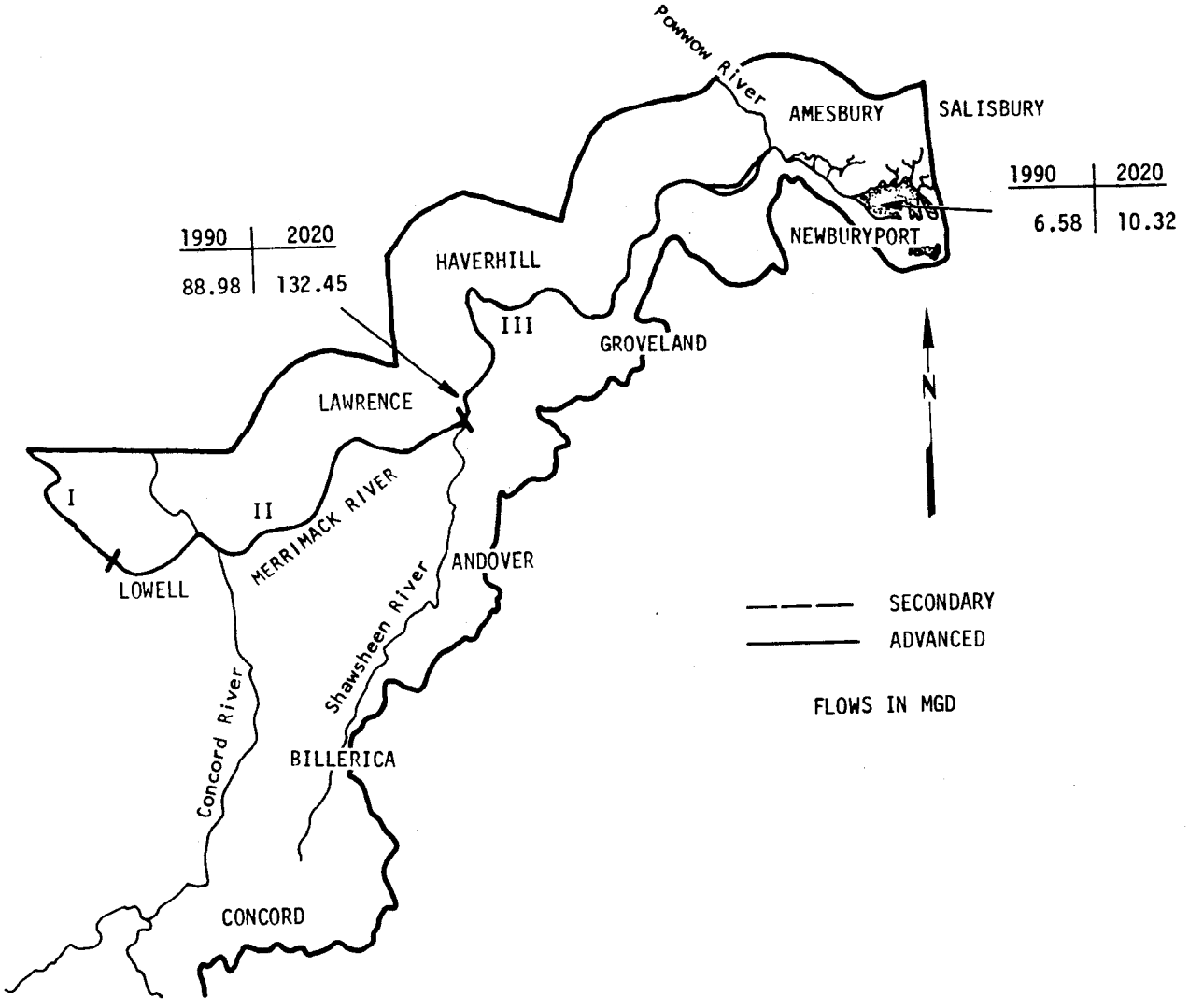

Figure 7. Wastewater inputs to the aquatic ecosystem - alternate 4. Water oriented regional.

TABLE 16.
ALTERNATE 4, WATER ORIENTED REGIONAL

PARAMETER	OUTFALL CONC. (ppm)	BASE LINE RIVER CONC.[1] CONCORD RIVER (ppm)	POWWOW RIVER (ppm)	MERRIMACK RIVER (ppm)	CONCENTRATIONS AFTER MIXING: CONCORD RIVER 1990 (ppm)	CONCORD RIVER 2020 (ppm)	POWWOW RIVER 1990 (ppm)	POWWOW RIVER 2020 (ppm)	MERRIMACK RIVER: AREA I STATE LINE TO PAWTUCKET DAM 1990 (ppm)	AREA I 2020 (ppm)	AREA II PAWTUCKET DAM TO ESSEX DAM 1990 (ppm)	AREA II 2020 (ppm)	AREA III ESSEX DAM TO ESTUARY 1990 (ppm)	AREA III 2020 (ppm)	CRITERIA (EPA AND SCIENTIFIC LITERATURE) (ppm)
Total Nitrogen	2.0	---[2]	---[2]	.35	---	---	---	---	.35	.35	.35	.35	.565	.652	---[3]
Organic Nitrogen	.5	---[2]	---[2] ---[2]	.5	---	---	---	---	.5	.5	.5	.5	.5	.5	---[3]
Ammonia	.5	.024	---[2]	.025	---	---	---	---	.025	.025	.025	.025	.087	.112	.02
Nitrate	1.0	.03	.01	.13	---	---	---	---	.13	.13	.13	.13	.24	.29	.3
Total Phosphate	.05	.0001	.001	.0055	---	---	---	---	.0035	.0035	.0035	.0035	.0096	.0120	.05

1 Above First outfall -- determined from existing conditions and projected upstream flows and treatment level.
2 No data available.
3 No criteria set.

proved water quality should have an overall positive impact.

g. Summary -- As with other alternates this alternate will significantly improve existing water quality, however there will be a significant localized impact in Area III.

F. Alternates 5 and 6 -- Aquatic Portion (see Figure 8, Table 17).

1. Physical

a. Concord River -- No significant environmental impact.

b. Powwow River -- No significant environmental impact.

c. Merrimack River Areas I, II, III, and Merrimack River Estuary -- No significant environmental impact.

2. Chemical

a. Concord River -- Removal of wastewater input will have a positive environmental effect.

b. Powwow River -- Removal of wastewater input will have a positive environmental impact.

c. Merrimack River Area I, and II -- Removal of wastewater input will have a positive effect.

d. Merrimack River Area III -- Input of AWT effluent at Lawrence will have primarily a local effect. During periods of low flow, it is possible that ammonia and chlorine toxicity will be present.

e. Merrimack River Estuary -- The overall impact of these alternatives on the estuary will be positive because of decreased water loading. However, it is not felt that introduction of secondary waste effluent to the estuary is environmentally sound. Ammonia will likely remain toxic for a longer period of time due to the higher alkalinity of the estuarine water. Residual chlorine and chloramines will probably have toxic sublethal effects on various estuarine organisms. Finally, chronic sublethal effects of some heavy

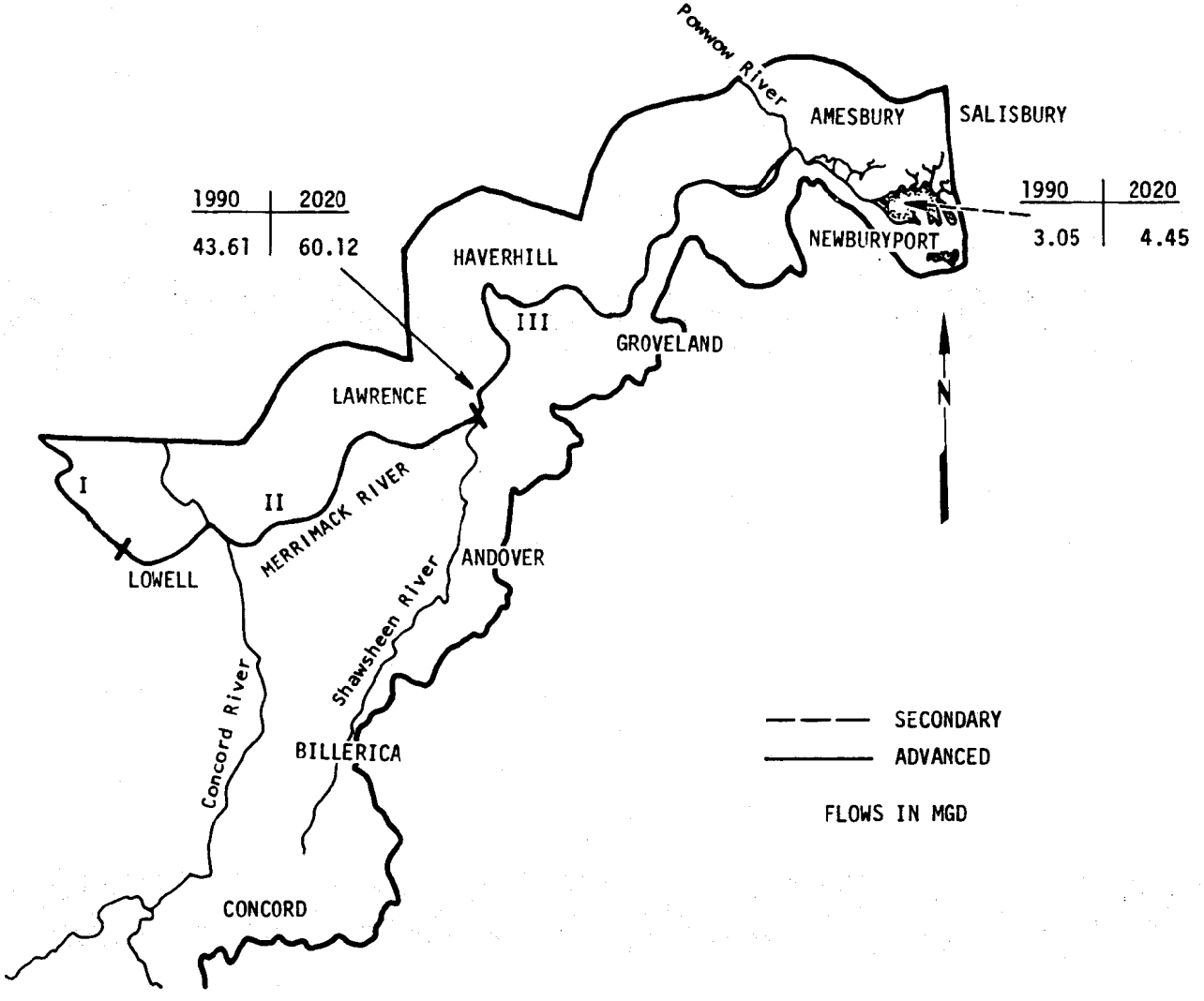

Figure 8. Wastewater inputs to the aquatic ecosystem - alternatives 5 and 6 land oriented system.

TABLE 17.
ALTERNATES 5 AND 6, AQUATIC PORTION OF LAND ALTERNATES

PARAMETER	OUTFALL CONC. (ppm)	AWT (ppm)	BASE LINE MERRIMACK RIVER	CONCENTRATIONS AFTER MIXING						CRITERIA
				AREA I		AREA II		AREA III		
				1990	2020	1990	2020	1990	2020	
Total N	20	2.0	.35	.35	.35	.35	.35	.5	.5-.6	---
Organic N	2.0	0.5	.5	.5	.5	.5	.5	.5	.5	---
Ammonia	9.8	0.5	.025	.025	.025	.025	.025	.05-.09	.07-.13	.02
Nitrate	8.2	1.0	.13	.13	.13	.13	.13	.19-.23	.21-.24	.3
Total Phosphorous	10.0	.05	.0035	.0035	.0035	.0035	.0035	.006-.05	.008-.07	.05
Phenols	0.3	---	---	---	---	---	---	.001	.002	.001
Cadmium	0.1	---	---	---	---	---	---	.0005	.0006	.004-.0004
Chromium	0.2	---	---	---	---	---	---	.0009	.001	0.1
Copper	0.1	---	---	---	---	---	---	.0005	.0006	.05
Lead	0.1	---	---	---	---	---	---	.0005	.0006	.05
Manganese	0.2	---	---	---	---	---	---	.0009	.001	.1

CONTINUED

TABLE 17. CONTINUED

PARAMETER	OUTFALL CONC. (ppm)	AWT (ppm)	BASE LINE MERRIMACK RIVER	CONCENTRATIONS AFTER MIXING						CRITERIA
				AREA I		AREA II		AREA III		
				1990	2020	1990	2020	1990	2020	
Mercury	0.005	---	---	---	---	---	---	.00002	.00004	.00005
Nickel	0.2	---	---	---	---	---	---	.0009	.001	0.1
Zinc	0.2	---	---	---	---	---	---	.0009	.001	0.1

metals will have a deleterious effect on estuarine organisms.

f. Summary -- Water quality in most areas will be improved under this alternate, however the presence of a secondary treatment plant discharging to the estuary is not felt to be environmentally sound.

APPENDIX O

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